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TABLE OF CONTENTS

Page

LEADING ARTICLES:

Flood Repairs to the Lehigh & Susquehanna Division of the Central Railroad of New Jersey (illustrated). M. A. Zook, M. Am. Soc. C. E..... 97

Notes on Railway Construction from the Resident Engineer's Standpoint (illustrated). F. C. French, Assoc. M. Am. Soc. C. E..... 98

Hot-Water Heating System and Table of Heat-Transmission Coefficients (illustrated) 102

Specifications for Acetylene Gas Generating Apparatus for Fort McPherson, Ga. 102

The New Ordinance for Fire Protection of Theaters in Chicago 103

Annual Meeting of the Canadian Society of Civil Engineers 110

The Ferrell Process for Preserving and Fireproofing Wood and Textile Fabrics. 111

Concrete Mixtures in the Big Muddy Bridge; Illinois Central R. R..... 111

Questions Asked in the New York Civil Service Examinations of Jan. 12, 1904 (illustrated) 111

Concrete Foundations and Cement Filler for Brick Pavement; A Comparison of Natural Cements and Portland. O. L. Gearheart 113

Automatic Tide Gates for the Bolsa Chica Gun Club, California (illustrated). Jas. D. Schuyler, M. Am. Soc. C. E..... 114

The Cache River Drainage Survey. A. H. Bell 115

Efficiency of Riveted Joints (illustrated). Gilbert S. Walker, M. E..... 116

Automatic Spacing of Rivet Holes (illustrated) 117

Floods and Flood Protection Works at East St. Louis, Ill. (illustrated). James F. Parr 118

The Wear of Sewer Inverts (illustrated). E. A. Hermann, M. Am. Soc. C. E.. 120

Page

ENGINEERING NEWS OF THE WEEK..... 103

EDITORIAL COMMENT.—A Consulting Engineer's Report in Favor of a Meter System——Why Railway Companies Should Publicly Advertise Their Contracts——Developments in Electric Smelting of Iron and Steel——Popular Misconceptions as to Methods of Combating Typhoid——The Deficiency in the Registration of Vital Statistics..... 104

EDITORIAL.—Estimating the Volume of Railway Traffic 105

LETTERS TO THE EDITOR.—The Results of a Break in a Canal Embankment (illustrated): Albert J. Himes——Removing Ice from Railway Tracks with a Steam Shovel: Gordon S. Meek——The Use of Marking Rods to Mark the Position of Sewer Branches: Alexander Potter——A Rule for Dropping Decimal Places: A. H. Horton——The Grand Forks Typhoid Epidemic of 1893-4: Gardner S. Williams, M. Am. Soc. C. E.——A Vest-Pocket Table of Strength of I-Beams and Channels Used as Beams: J. A. Holmboe——Is the Cost of Sewer Trenching a Function of the Depth of the Trench? W. S. Kirchoffer——Effect of Removing Cement Briquettes from Water for Varying Lengths of Time Before Breaking: H. P. Boardman——Tests of Cement Mortar Made from Sand Containing Alkaline Earth: J. M. Lewis——The Deterioration of Concrete in Coke Oven Foundations: Chas. H. Hoyt, C. E.——The Use of Rakes in Mixing Concrete: W. T. Hardison, Jr.——Mixing Concrete by Hand: Ernest McCullough——Methods of Finishing the Surface of Concrete: Henry H. Quimby, M. Am. Soc. C. E.——Automatic Stops as Adjuncts to Block Signal Systems (illustrated): Geo. G. Wacker——Concerning Requirements for Admission to Engineering Societies: "A Western Engineer"——Cost of Maintenance of the Union Engineering Building: F. S. Odell; The Union Engineering Building; Questions of Finance: "Member"——The Proposed Union Engineering Building: Reginald Pelham Bolton, M. Am. Soc. C. E.——Notes and Queries.....106-110

FLOOD REPAIRS TO THE LEHIGH & SUSQUEHANNA DIVISION OF THE CENTRAL RAILROAD OF NEW JERSEY.

By M. A. Zook,* M. Am. Soc. C. E.

The Lehigh & Susquehanna Division of the Central R. R. of N. J. extends from Easton, Pa., to Scranton, Pa., a distance of 119 miles, following the Lehigh River from Easton to White Haven, a distance of 70 miles. The line generally parallels the Lehigh Valley R. R. between the above points, the two roads lying on opposite sides of the river and crossing each other at Allentown, Lehighton, Coalport (west of Mauch Chunk), Penn Haven and White Haven.

The Lehigh Valley was visited by severe floods on Dec. 15, 1901, and Feb. 28, 1902, carrying out old dams below White Haven, and causing damage to the railroads, as well as to the towns and industries in the valley. This damage extended from Easton, Pa., to White Haven, Pa. The principal damage to roadbed was between Mauch Chunk and White Haven. The damage to bridges covered the entire distance from Easton to White Haven. The Lehigh Valley Railroad lost two spans of its bridge at Penn Haven, and one pier and two spans of its bridge at White Haven, and besides suffered much damage to its roadbed. The Central R. R. of New Jersey lost its bridge at Easton, two bridges at Allentown, one at Glen Onoko, one at Penn Haven, and in addition sustained damage to the masonry and foundations of its bridges at East Allentown, West Allentown, Northampton, Weissport and Nesquehoning Junction and other points.

Traffic was delayed on both the Lehigh Valley R. R. and Central R. R. of New Jersey, but fortunately the two roads were able to use each other's tracks between the points of most serious disturbance.

The damage to the roadbed of the Central R. R. of New Jersey consisted of scouring and cutting the embankments, thereby causing the loss of one track at a number of points. This damage was generally repaired with rock quarried from the mountain sides, and delivered by trains. The most important places were at Mauch Chunk Narrows, below Mauch Chunk, and between that point and Rockport. At such points the rock was quarried from the face of the adjacent bluff with power drills, thus forming a new roadbed, besides obtaining filling material for other points. Fig. 1 is a view showing the work at Rockport. The repairs to roadbed were completed during the summer and fall of 1902, and aggregated approximately 400,000 cu. yds.

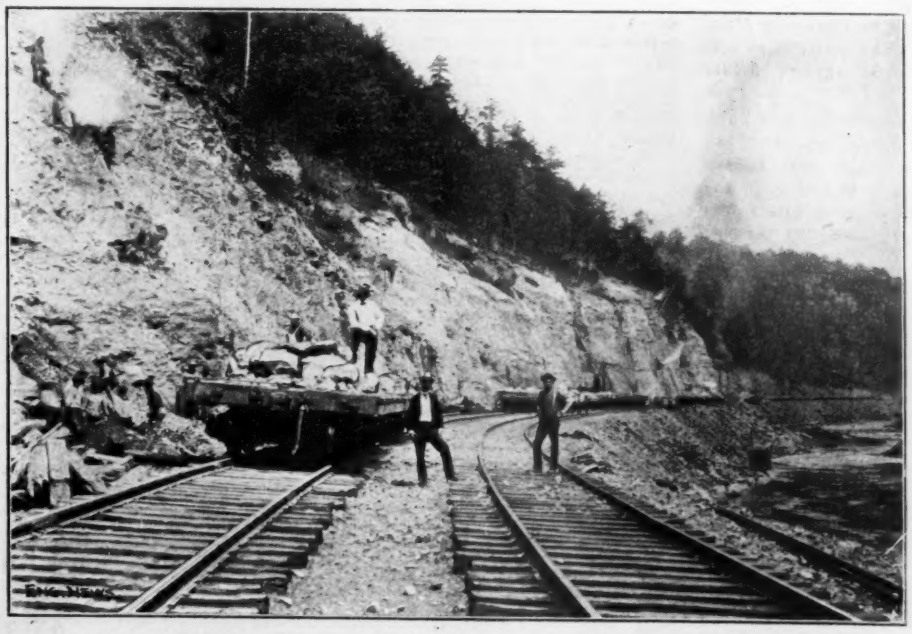

FIG. 1. RECONSTRUCTION OF FLOOD DAMAGED TRACK BY BLASTING OUT BLUFFS; CENTRAL R. R. OF NEW JERSEY.

The repairs to bridges were not completed until the summer of 1903, and included the construction of new piers and abutments, the underpinning and reinforcement of old piers and abutments whose foundations had been undermined or damaged, the construction of retaining walls, etc. All masonry was repaired or built with concrete, using Atlas Portland cement, with concrete in the proportions of 1 part cement to 3 parts sand and 5 parts stone; except in special cases of foundations, where the mixture was in some cases made 1, 2 and 4.

The views Figs. 2 and 3 show the wrecks of the bridges at Easton and Allentown. The bridge at Penn Haven was carried out in December, 1901, and the other bridges Feb. 28, 1902. The break at Easton was the most serious. This bridge over the Lehigh River consists of two deck spans and one through span, with a viaduct approach at the west end. The through span extended over the county highway bridge at Third St., Easton. The east pier and middle pier, of first-class masonry, were built on timber cribs filled with stone and concrete, and founded on gravel and boulders, overlying the bedrock, and protected with riprap.

Upon Feb. 28, 1902, the flood, assisted by the ice, undermined the crib of the center pier, which fell, carrying with it the 176-ft. through span and the 160-ft. deck span. The 176-ft. through span, after sliding 7 ft. out of line, was caught by the highway bridge. The end of the span was wrecked, and the balance badly twisted and damaged, as is shown by Fig. 2.

At ordinary stages, the water at this point is 20 ft. deep, but during the flood the depth was from 30 ft. to 35 ft. On account of the high water and swift current, progress in clearing the wreck was slow. Much time was lost removing the debris, and blasting under water had to be frequently resorted to.

The temporary structure consisted of pile bents, with an upper story of framed bents. Driving the piles was slow and difficult on account of the wreckage. The first piles were driven March 14, and the temporary double-track structure completed March 27.

The other piers were slightly damaged, the east pier being partly undermined. This foundation was repaired by divers, with concrete in bags, and further protected by a heavy coat of riprap. The structure was rebuilt with a concrete pier, the foundation of which is on bedrock, 71.4 ft. below base of rail. The foundation is 21.7 ft. by 72.6 ft., and top of pier 13 ft. by 60 ft. This pier contains 2,200 cu. yds. of concrete. The pier was built by means of an open cofferdam, consisting of a single line of 6 × 10-in. tongue and grooved sheeting, driven by a pile driver. Great care was taken with the concrete, especially during cold weather, when the materials were kept heated. The pier was built by the F. M. Stillman Co., Contractors, of Jersey City. The new superstructure was fur-

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nished and erected by the Phoenix Bridge Co., of Phoenixville, Pa.

Two riveted deck spans of one of the bridges at East Allentown were raised and repaired and a concrete pier built under them. These spans had some members broken, and were raised by driving pile bents on each side of each span and for the new supports. A bent was then erected over the spans, and the spans then raised and slid into line.

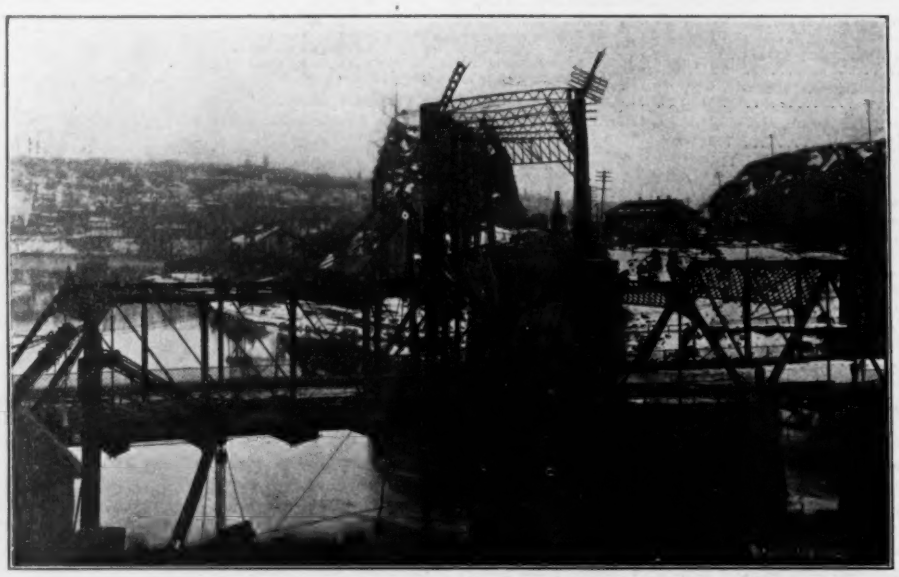

FIG. 2. WRECKED RAILWAY SPAN SUPPORTED BY HIGHWAY BRIDGE, EASTON, PA.

The foundations of the piers and abutments of the bridges at Weissport, Nesquehoning Junction and Penn Haven were underpinned and reinforced with concrete, in the general manner shown by the plan of work at Weissport, Pa., Fig. 4. Cofferdams were built at each point and the new foundations carried to such depth and material as was thought satisfactory and safe against future scour.

At Glen Onoko an entirely new bridge was built, with concrete piers and abutments and three 80-ft. double-track plate girder spans. The Lehigh River at this point is crooked, rapid and deep, and subject to frequent freshets. Some difficulty was experienced on that account. On account of floods and ice, the piers were protected with steel cutwaters, as shown by Fig. 5. The east pier was founded on large boulders and gravel, and the west pier on bedrock. The foundation of the east pier was solidified by pumping cement through the cofferdam into the rock and boulders,

Beginning with the emergency work at Easton, the work was under the charge of the writer, acting under directions of the Chief Engineer Central R. R. of New Jersey.

NOTES ON RAILWAY CONSTRUCTION FROM THE RESIDENT ENGINEER'S STANDPOINT.*

By F. C. French,† Assoc. M. Am. Soc. C. E.

The object of this paper is not to state the practice of any particular road, but to call attention to the points of difference of a number of roads, points ignored by a great many. Minor items may be given undue importance simply to call attention to their general neglect of mention. Such a comparison, based upon some years of actual experience, must of necessity be out of date in some instances, and to avoid this, I have recently obtained the current practice of 15 roads west of Chicago from their Chief Engineers, and compiled results therefrom.

WIDTH OF RIGHT OF WAY.—Assuming, then, that the great economic question of location has been properly solved, the resident engineer arrives upon the ground and is confronted with a company agent who is bargaining for right of way and promising crossing concessions at impossible places in exchange for a small reduction in the price per acre, and working under instructions to secure a uniform width of 100 ft. of way, regardless of streams, borrow pits, waste banks, or other difficulties.

The author has gleaned from experience, but has been unable to verify his judgment from many other sources, the following requirements as to widths of right of way required, and tries to impress the right of way agent with their importance:

Cuts with waste banks:

4 ft.	to 6 ft. deep,	100 ft. of width.
6 "	to 8 " "	120 " " "
8 "	to 10 " "	140 " " "
10 "	to 12 " "	160 " " "
12 "	to 14 " "	180 " " "

With a probability of damages to adjacent property from wash of waste banks an additional width of 10 ft. to 20 ft. is necessary. A width of at least 200 ft. is also advisable at the crossing of all important streams.. When owners of land will sell the earth off of additional ground wanted at a reasonable figure, 100 ft. of width will be ample, as a double-track railway with slopes for excavation and embankment can be placed thereon, but the 200 ft. at streams is important in either case.

SOUNDINGS AT STREAM CROSSINGS.—Before actual construction begins the sites of all bridge openings should be sounded to determine the character of the foundations required, and from these results, bills of material made out and requisitions for same sent to the chief engineer.

The soundings may readily be made by a party of three men and foreman, provided with the following equipment: One team and wagon, one sounding rod (sectional), one drill (1-in. bar 8 ft. long), two pipe wrenches, two rod clamps for raising rod, two water pails, one axe, and one spoon.

A convenient sounding rod is made by the ordinary pipe fitter, by taking sections of 1-in. gas pipe 10 ft. long and into each end of each section welding a 6-in. piece of ¾-in. gas pipe, so that the end projects ⅞-in. This end is then threaded on the outside and connection of sections made by uniting with an ordinary ¾-in. union 1⅝ ins. long, threaded inside.

The drill is a 1-in. rod 12 ft. long and pointed as an ordinary rock drill, with its cutting edge widened to 2 ins., 1 in. back from point and tapering back to shank. The shank is then drawn out to ¾-in. and threaded to fit an ordinary union. Several drills should be provided to avoid delays of working with dull tools. A couple of small holes near bottom end of pipe attached to drill will relieve air pressure when lifting in a sticky hole. This sounding rod and bit can be used as an ordinary churn drill.

The clamps are pieces of iron similar in shape to an ordinary wrench and made to fit pipe snugly so that when a lever is put under the handle end, the clamps will jam the pipe and the pipe be withdrawn.

Two clamps are used to relieve bending strain. Where rock is near the surface, pits will give much better results. Notes of the position of the pits or soundings as well as depth and character of material encountered must be taken on the spot and plotted later in the office.

CHECKING LOCATION SURVEY.—The resident engineer's force as a rule consists of an instrumentman, a rodman, tapeman, team and driver, and he should as quickly as possible have them check all curves and tangents and put in spirals (see Spirals). The length of spiral depending on the road in question to some extent. Run check levels over the residency and report at once any errors found in location levels. Put a bench mark close to each bridge for cut-offs and foundation elevations. Engineers must carefully reference the beginning and ending points of all curves and points of compound curve; also all other important points. This may be done by setting two hubs at angles of 45° and 135° on each side of the tangent, say 100 ft. from the P. C. or P. T. The hubs should be driven down level and guard stakes placed for witnesses. In this manner the point may be replaced by measurement or intersection or both. In timbered country the reference points may frequently be

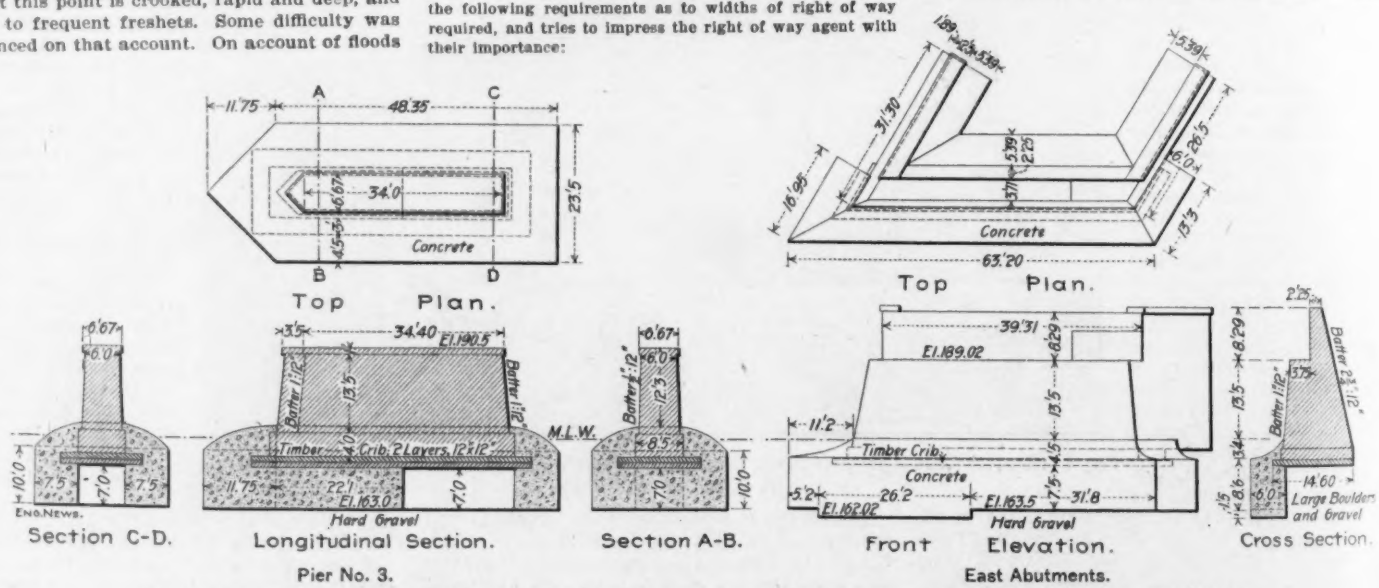

FIG. 4. METHOD OF UNDERPINNING AND REINFORCING BRIDGE PIERS AND ABUTMENTS AT WEISSPORT, PA.

For banks from:

6 ft.	to	8 ft.	in	height,	120 ft.	of	width,
8 "	to	10 "	"	"	140 "	"	"
10 "	to	12 "	"	"	160 "	"	"
12 "	to	14 "	"	"	180 "	"	"
14 "	to	16 "	"	"	200 "	"	"
16 "	to	18 "	"	"	220 "	"	"
18 "	to	20 "	"	"	240 "	"	"
20 "	to	22 "	"	"	260 "	"	"
22 "	to	24 "	"	"	280 "	"	"
24 "	to	26 "	"	"	300 "	"	"

*A paper read at the annual meeting of the Iowa Engineering Society.

†Humboldt, Iowa.

placed on tree roots for greater safety, blazing tree for witness.

CROSS-SECTIONING.—All cross-sections should be entered in the cross-section book as taken. Even if the cross-sectioning cannot be carried continuously across a residency, the entries should be made as though it were continuous, leaving two or more blank leaves at the end of each mile to be used for a summary. Each piece of cross-sectioning should be carefully indexed in the cross-section book, station to station.

Vertical curves should be calculated before the cross-sectioning is done for all grade intersections, and in sags noted and added to the sum total of the yardage. Sections should be taken at each mile post for convenience in making estimates.

The engineer should keep a transit book, level book, field cross-section book, bridge book, pile record book, and diary and a field entry of notes on paper or memorandum, for future entrance in the record books should never be practiced or permitted by an assistant. Taking a simple record of notes in memory and failing to record same has probably brought more otherwise good engineers into disrepute than any other one thing. I once heard a chief engineer say very forcibly that a large majority of his men would become good engineers only when they had some one to cut off their heads and send them to the office files.

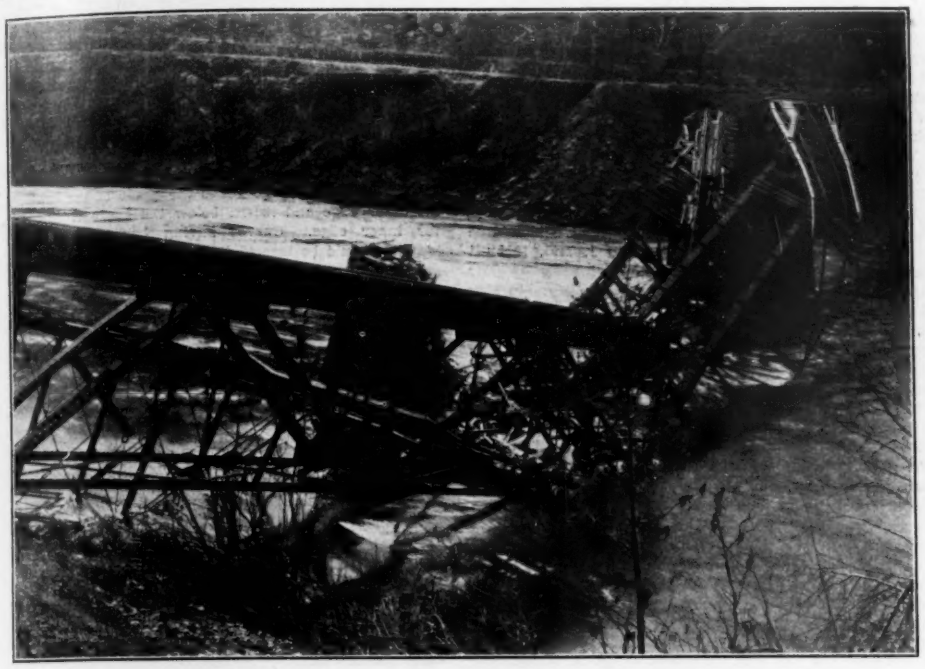

FIG. 3. WRECK OF RAILWAY BRIDGE OVER LEHIGH RIVER AT EAST ALLENTOWN, PA.

the rate should not exceed .10-ft. per station. On summits in cuts the rate should be sharper to facilitate drainage. On all vertical curves the grade elevation of each full station and + 50 ft. should be entered on the profile as well as in the level and cross-section book.

Cross-sections should be taken and slopes set at every point where a difference of elevation of center line of the two sections exceeds 2 ft., and always every 50 ft., treating half stations as though they were full ones. In marking stakes, have the station number on face of each center stake and cut or fill on the back. On slope stakes have the cut and fill on the face and station number on back. Have + stations marked with the last figure of the preceding station, with the +, thus: for station 165 + 50, mark 5 + 50.

Take cross-sections and set grades where the shallow side of cut runs to grade and where shallow side of fill does the same. It is usually sufficient to note the plusses where the deep sides of cut and fill come to grade, but the author always follows the practice of setting grades. Where it is expected to strike rock or its equivalent, the preliminary cross-sectioning may be made at a slope of ½ to 1, which will in part compensate for the irregular or compound sections that develop on construction.

All embankments at bridge openings should be staked out 2 ft. wider than specifications and tapering back to the standard in 50 ft., and as these banks are more exposed to wash, they should be carried out wedge-shaped instead of the usual rounded corners. This gives footing material for support of the outside corners of the roadbed.

Exceptionally high banks should have the allowance for shrinkage made in width when cross-sectioning, which will give a good footing for additional material placed in bringing up to a true grade after settlement has taken place and the road is in operation. A number of western roads put all shrinkage on in width when staking out the work and only bring dump to the true profile grade, claiming that they have a better bed after settlement and sufficient supporting room to raise to true grade with train service and in ballast.

All isolated masses of rock which occur between stakes, but not included in regular notes, should be separately noted and added to the sum total of the yardage. Sections should be taken at each mile post for convenience in making estimates.

The engineer should keep a transit book, level book, field cross-section book, bridge book, pile record book, and diary and a field entry of notes on paper or memorandum, for future entrance in the record books should never be practiced or permitted by an assistant. Taking a simple record of notes in memory and failing to record same has probably brought more otherwise good engineers into disrepute than any other one thing. I once heard a chief engineer say very forcibly that a large majority of his men would become good engineers only when they had some one to cut off their heads and send them to the office files.

A title should be written on the fly leaf of each book, giving the residency number, resident's name and address, with a brief statement of what the book is used for. Each page must be numbered and dated for each day's entry and indexed in front of book for each separate piece of work.

"Nothing new under the sun," can be said about the methods of taking notes, but it is a subject which has been sadly neglected, and the author gives below, with apologies, a method which he has arrived at through the fog of many experiences.

LEFT HAND PAGE.

Cross Sections.		
L.	C.	R.

RIGHT HAND PAGE.

Sta.	Elev.	Grade.	Areas.		Cu. Yds.	
			Cut.	Fill.	Cut.	Fill.

In the diary should be kept careful and conscientious record of the work done on that date by themselves and parties and the location, amount and nature of the work done by various contractors.

It frequently happens that a controversy may arise between the contractors and company concerning the amount of extra work, delays, hindrances, etc., which came up during the progress of the construction, and the object of these diaries is to have at hand a record of these points which at any time in the future may be consulted and from which the justice of the claims may be determined.

Particular care should be exercised in keeping a careful record where any cut has in it a questionable material that might claim classification. In such an instance the diary should state plainly at what times the cut was inspected, how frequently during the day, what force was at work, what progress was being made, what special difficulties encountered and the different locations and amounts of any material considered by the engineer as entitled to classification under the specifications. Particular attention being given to the number, appearance and condition of the plow stock, as this is a common point of determination between classified material and earth. The diary should also show a copy of all instructions given to contractors verbally, and any other items pertinent to a record of the work and a comprehensive estimate of same when completed, bearing in mind that this is a most important part of the final record.

The diary should also embrace a careful report of the weather and ground conditions, as this is frequently a factor in claims for an extension of time, by the contractor. Also, in this connection, the engineer should go over the ground during or immediately after any unusual or record-breaking storms and note carefully the amount of rainfall reaching the openings in his track, damage done, etc., etc., to determine, if possible, any necessary changes in the size of his bridge openings. A careful inspection on the ground is worth more than the evidence of a number of men, years afterwards, who did not have a particular reason for noting the extreme heights of floods, etc.

CLEARING AND GRUBBING.—Clearing must not be piled off the right of way without first securing consent from the owner in writing, which must be forwarded to the chief engineer for his files; nor within the reach of high water which might float it back into the openings, always bearing in mind that in flood districts there is a current both ways. In clearing, make allowance for telegraph lines, which are usually 45 ft. from the center line. Dead or leaning trees outside the right of way, which, if blown down, would wreck the wires, should be cut, and damages, if any, allowed to the owner. Grub holes under the embankment made by blasting shall be carefully filled and tamped, and the use of powder for "shooting stumps" under embankments must be restricted and discouraged, grubbing being much preferable.

While the cross-sections are being taken the location and height of stumps to be grubbed should be noted and the location fixed by measurement and sketch, so that they may be sounded for later on, and, if covered by the contractor, ordered removed before acceptance. The specifications as to height of stumps and the burning or removal of grubs should be rigidly inforced.

ROADBED EXCAVATIONS.—The engineer will give centers through the excavations as the work progresses in order to insure the contractor's excavating to the required slope, and he will not allow plowing to be done nearer than 1 ft. to the slope, and all slopes must be cleaned down and dressed as the work progresses, if the material will permit. Slope boards must be used in this work and will be furnished by the company for the use of the contractor, and will be returned to the engineer as soon as the work is completed.

If, as the work progresses, the character of the material changes so as to require a different slope or roadbed, the engineer must re-cross-section the work without delay and take sufficient measurements to enable him to calculate accurately the material excavated.

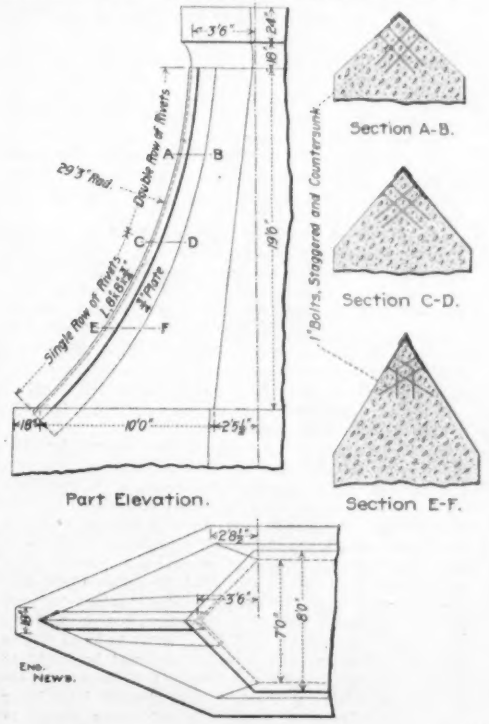

Fig. 5. Method of Arming Cutwaters of Bridge Piers at Glen Onoko, Pa.

When excavation is in excess of embankment within the haul limits, the embankments should be proportionally widened to take the material, if, in the judgment of the engineer, the increase in width is not exceeded in value by the price of over-haul. It should be thoroughly understood by the engineer that all material may be hauled at his discretion up to the point where over-haul exceeds the price of excavation.

In cases where banks are so low as to make haul impossible within the price, material may be wasted under due precautions to place it in such a way that it may not

be washed back into the cut. Wasting material is objectionable in many ways and will only be resorted to when it cannot be avoided, and in such cases the banks must be left in regular and sightly shape, not nearer than 15 ft. to the slope stakes and never permitted at the mouth of cuts. Line the back of waste banks, leaving a liberal fence berm.

Whenever embankments are in excess, cuts within the limits of free haul and at the discretion of the engineer for a reasonable distance beyond, should be widened for the material and provision made therefor in the cross-sectioning.

All change channel work and ditching shall be staked out in advance, and liberally, so that the contractor will have no excuse for filling everything in sight from borrow. It cost the contractor an additional price to widen a cut or ditch after it has once been excavated, and as it it to your interest as well as his to see that he makes as large a profit as possible within the requirements of his contract, you should never by your carelessness entail upon him this additional expense.

At passing tracks and switch stands, both cut and fills should have an additional width of 3 ft. for distances of 50 ft. toward the station and 200 ft. away from it, to enable the brakemen to overtake the train after throwing the switch.

While the work of finishing is being done the engineer should see that all rock cuts or cuts having boulders in the bottom should be taken out 1 ft. below sub-grade and that the cut is full width on bottom to allow for a good ditch. After the cut is taken out, the roadbed should be filled in to grade with the best material at hand.

The engineer may require the contractor to place in suitable piles and at places as he may direct, any material suitable for riprap, slope, wall, foundations, etc.

In making these piles, place them at 90° to the track and leave runways of 4 ft. width between piles to facilitate rapid loading by work train crews later on. Contractor should be allowed a suitable amount for such sorting and piling.

The use of large quantities of powder in pot holes, seams, shaft or drift shots may be restricted within the judgment of the engineer, in order to protect the slopes or the earth banks on compound sections. In an ordinary cut of, say, 6 ft. of earth over 8 ft. of rock, the centers should be fired first and the material mucked out and then the cut widened by light side shots to avoid shattering slopes.

SURFACE AND DRAINAGE DITCHES.—In few matters is there more of an opportunity for an engineer to exercise good judgment in construction than in the question of drainage, including the disposal of surface water above and in cuts, above embankments on side hill work, and the straightening and possible changing of channels in streams. A very slight change in profile of a line will often create or eliminate a vast amount of expense in the maintenance later on.

Liberal surface ditches will be staked out on the high side of all cuts and excavated before the work of excavation of the roadbed has been more than well started. The material excavated therefrom will be placed in a continuous bank or levee between the ditch and cut and leaving a 3-ft. berm between the ditch and bank, thus adding to the capacity and value of the ditch. No surface ditch should be less than 2 ft. wide on the bottom or less than 1½ ft. deep. All ditches should be carried to a borrow pit or water course or turned away from the embankment below the mouth of cut.

When embankments are made from excavation and there is no borrow pit, berm ditches will be excavated and made of ample dimensions for the requirements of the location. All ditches must be staked out and in general the material excavated from them placed in the embankment. In change channels for turning streams, care must be taken to make embankments across the old channel of sufficient width to withstand the action of the current. In such cases, the width of the embankment should usually be not less than 20 ft. on top, with a slope of two to one, bearing in mind that it is cheaper to build a dyke too strong than to have it washed out and be forced to replace it. In turning rapid turbulent streams, take especial care to prevent the new embankments from being washed away before they are high and strong enough to withstand the current.

EMBANKMENTS.—The clause in the ordinary specifications which requires the embankments to be built out to the slopes from the base up, so that the whole will settle compactly, must be rigidly enforced. The contractor will, if left to himself, carry up his centers and then widen by dumping over the sides in order to make a neat looking job, and, if paid by embankment measurement, will figure that he puts in less yardage in that manner, which is true, but he is paid to bring his dump to a true prism and if kept out to slopes from base up will have no difficulty with concave slopes or "sloughing off" from his shoulders.

The best material must be placed under the center of the roadbed and the poorest under the slopes, using care with material liable to a large shrinkage, such as sod, frost clods, etc., to have them no farther in from the slopes than they are below grade. See that sod and surface material from cuts are not placed in the shallow part of the fills, but carried farther along where bank is high.

When necessary to work in freezing weather, see that the material is kept constantly plowed to minimize the freezing, and when wheel scrapers are used on high banks, see that the runways are carried up the full width of banks in order to get uniform compacting by the travel.

The shrinkage varies greatly with different authorities and also the method of applying the same to embankments. A safe plan is to widen the banks from slope stakes up and then correct the grade line after settlement with ballast, or otherwise. The average shrinkage used on most roads is 5% for scraper work, 7% for wagon work, and 10% on casting and grader work without wagons.

The use of grading machines, elevating directly to dump, may be allowed when the layers are limited to not more than 8 ins. in thickness before compacting. Each layer must then be compacted by a harrow or heavy roller, or both, as may be necessary, in the judgment of the engineer.

When fills are less than 2 ft. in height the sod from the top of borrow pit or cut to a depth of not less than 3 ins. should be wasted if machine is used.

RIPRAP.—When embankment must of necessity be riprapped to protect it from the action of water, it should be built at a slope not greater than 2 to 1, and, if built steeper, the riprap should be placed with its exterior face at that slope and be well backed for safety. In case the base of the riprap rests on rock, a steeper slope is permissible, but seldom less than 1½ to 1. The riprap stones should be placed with the larger ones at the bottom and laid by hand with considerable care to avoid large openings. The stones should measure 1 cu. ft. at least, and at the ends should be turned into the bank for a couple of feet to avoid undermining or washing out.

BORROW PITS.—No borrowing of material will be permitted on the station grounds without express permission from the engineer, and no pits will be made where they might cause injury to the embankment. Where necessary, they will be made on the outside edge of right of way and not excavated below the bottom of openings through which they are to drain, and the contractor must be instructed how to excavate them so that they will drain themselves for their entire length, if necessary grades should be run for this.

Borrow pits for light fills should be narrow and deep to diminish the per cent. of sod in the fills. Commence all pits at least 3 ft. farther from the bank than the berm specified, because the scrapers will drag off the corners and the contractor's tendency is to cut the berm down at all times. The quantities to be borrowed are arrived at from the plotted haul and the contractors are to be instructed how much and when to borrow so that the borrow will not be excessive, leaving the cuts to be wasted.

Berms of the following width should be left between the slope stakes and borrow pits: Banks under 3 ft., 6 ft. berm; banks 3 to 10 ft., 8 ft. berm; banks over 10 ft., 10 ft. berm.

CROSSINGS.—In locating crossings consult the right of way deeds and comply with the stipulations contained therein. Grades on crossings should not exceed 6% with 20 ft. of level, grade on each side of center line of track. The usual width of a farm crossing is from 12 ft. to 20 ft., and of a highway crossing from 20 ft. to 36 ft. on different roads, with the usual roadbed slopes. The engineer should endeavor to secure, within reasonable expense, under or over-head crossings. Bridges and culverts can usually be utilized for farm crossings, at least, with but small outlay.

FINISHING.—All grading will be finished to the standard roadbed sections, and slopes should be dressed to true prisms, both in cut and fill, no concave slopes in fills or cuts being permitted. In finishing embankment the author has made a practice of setting shoulder stakes at each station and center hubs at each + 50 on tangents, and on curves two stakes, one on each side at extreme width of cut at stations and plusses. With some contractors he has found it necessary to set crown stakes for the roadbed in cuts also. Before accepting, the grades over finished work should be checked and attention paid to the ditches to see that they have proper width and depth. Any method of finishing that will disturb the grade stakes will not be permitted. Where road is to be ballasted, in order to facilitate drainage, the roadbed at sub-grades should be crowned both on tangents and curves by raising the center 4 ins. above the sides, making due allowance for ballast in establishing grade elevations.

MASONRY.—In staking out masonry the stakes for the neat lines should be set far enough back from work to permit of its being carried on without interference with stakes and in such a position that lines stretched between tacks will intersect at the neat corners. The working plan furnished the contractor's foreman must show location of all stakes. The slope stakes should be set at such points as will reasonably prevent caving during construction, and the cross-sections taken in squares over a larger area so that in case caving occurs a complete record of the surface is at hand. Stakes should not be set on these squares, but the slopes set independently.

All foundation courses must be spread well below the frost line, unless placed on solid rock and in concrete foundations without grillage the excavation should be of dimensions equal to the footing course, while in stone masonry excavation should be made 1 ft. larger each way than the dimensions of the footing course.

A complete record and sketches of all masonry must be kept, particularly of the foundations which will be covered up later on. The depth in every case must be given below some fixed point, such as coping or bridge seat. In all cases of uncertain foundations special instructions will be issued by the chief engineer.

SUPER-ELEVATION OF CURVES.—On all curves the roadbed is to be furnished to conform to a super-elevation equal to 2% of the width of the roadbed for each degree in the index of the curve. The outer edge of the roadbed will be raised above the grade at the center line; half the super-elevation and the inner edge of the roadbed will be depressed below the grade at the center line half of the super-elevation, the center line remaining in conformity with the profile grade, plus shrinkage. Thus: For a 16-ft. roadbed on a 4° curve, the super-elevation would equal 1.28 ft. or .64-ft. above the grade of the center for tht outer edge and .64-ft. below the grade if the center for inner edge. Curves having bridges within their lengths should be treated in the same manner as at other points, the grade line of the bridge being adjusted in accordance with the above rule. The distance out in both cases will be set at a point corresponding with the width of roadbed desired, which in general will be 16 ft. on embankments and 8 ft. each side of the center line. On sharp curves proper correction should be made in the slope stakes due to the super-elevation. It is is desired that embankments shall be full and strong on the outside of all curves.

CULVERTS.—All culverts should be laid out at right angles to the center line when possible, and have their foundations below the frost line and at sufficient depth and grade that the culvert will drain itself and, in general, the borrow pits adjacent. Every culvert must be placed so that it may safely work under a moderate head without injury to itself and at as large a grade as the nature of the ground and its safety will admit. Both ends should be protected by a sunk wall extending at least 3 ft. below the floor and the lower end must be protected by an apron or some arrangement to keep the back-wash from undermining.

Vitrified pipes, when used, must be at least 3 ft. below sub-grade and crowned a few inches at the center. The bottom of the trench for pipe must be rounded and holes dug for the sockets. In case the foundation is poor, it must be excavated and suitable material placed. Stone in contact with the pipe must never be permitted.

When filling over pipe use drag scrapers to build up walls parallel to pipe and as close as possible to each side, giving the space over the pipe a more moderate packing. This will imitate to a degree the usual practice of pipe laying in trenches. When two rows of pipe are used they should be far enough apart to admit of thorough work between them.

Blind drains are sometimes made of rough stones thrown in without particular order and covered over with brush or sod. Their use is objectionable, however, and should be restricted to few cases.

PILING.—All pile bridges should be staked out ahead of the driver, setting a hub for center of each bent and a stake for each pile, being careful to use the near face of pile for the station, as centers can then be plumbed up from the hubs without the continual use of an instrument.

Pile inspectors should be appointed by the engineer, whose duties are to watch the driving of all piles and keep a record of each, seeing to it that every pile is driven deep enough to be secure against wash and scour as well as against sinking under the load.

The inspector will be provided with a pile record book in which he will keep a careful record of the bent number of each pile, and the pile letter, together with sketches of all pile foundations other than trestles, in order that the piles in the record may be identified. The bents will be numbered consecutively, the bank bent being (1) and so on, and the piles in each bent lettered A. B. C. D, etc., from left to right when looking with the stationing. The pile record will then show on the left-hand page: (1) Station; (2) bent number and pile letter; (3) length put in leads; (4) kind of pile and whether treated or untreated; (5) penetration below surface; (6) length below cut-off, to be filled in later; (7) penetration under last five blows; (8) weight of hammer and last drop in feet.

On the right-hand page all remarks on the progress and method of conducting work should be made.

The pile inspector will see that long piles are not used where shorter ones are ample, and that due precautions against brooming are used by having the heads well chamfered or pile rings used. In hard driving piles should be shod.

A good formula for safe load in pounds is $\frac{2\,W.\,H.}{S+1}$, in which W. = weight of hammer in lbs.; H. = fall in feet; S. = set of pile in inches under last plow.

When leaving a residency, the inspector will turn over

the records to the resident engineer, who will hand them in with his final notes. Where piles are driven by the company, the company foreman will keep the records of the inspector.

CUT-OFFS.—In setting cut-offs on curves, drive a tack in pile under the inside rail at some convenient whole number of feet below the cut-off, blazing the pile around tack and marking on it the number of feet up to cut-off, the distance being recorded in the notes. The outside pile is treated in the same way, allowing for the elevation.

On tangents, drive a tack in the two outside piles in a similar manner and let the sawyers line up the remaining inside piles. In every case the distance from cut-off to top of pile must be noted, as this, with the pile record, fixes the length of pile in bents.

TIMBER STRUCTURES.—All timber must be free from wanes, shakes, large knots, rot, or any defects which will impair its strength and durability; must be sawn square and be of proper dimensions, all imperfect sticks being rejected where they may be placed under transverse strain or tension.

Frame trestles will usually have foundations of piles and where, in the judgment of the engineer, piles cannot be driven mud sills will be permitted. Where mud sills are used all beds must be in excavation and to secure this "step bents" are sometimes necessary. Care must be taken to avoid covering any part of a sill with earth.

Care must be used in the framing of all timbers, as shimming will not be permitted, all adjustments of heights due to settlement being made by jacking up from below. In general: (1) Foundations must be firm and unyielding; (2) bents must be jacked and braced to right line; (3) cut-offs must be true and piles water tabled; (4) all timbers must be placed to a true and full bearing on piles and other timbers; (5) ends of caps and ties must be sawed to line from end to end of bridge; ties sized to full bearing, without shoulders, over the entire chord, guard rails well secured in line; (6) sway bracing must be ample and well bolted and spiked; (7) the whole structure must be in good line and surface, completely bolted and washered, waterways well cleaned out and all framing so arranged that water is not retained.

QUANTITIES.—The engineer must calculate the quantities as the work proceeds and as a rule the end area methods will be sufficient. For this, as before stated, the sections should be taken as often as the difference in elevation of the center line exceeds two feet.

In the calculations where the solid has only one end area, as at the end of a side hill cut, you should calculate as a pyramid instead of a wedge. As a check, see that the sum of pay quantities less the waste equals the total

TABLE I.—Giving Prismoidal Corrections.

Diff. in Cent. Hts.	Correction in cu. yds. per 100 ft. Stations for slopes of— ¼:1	½:1	1:1	1½:1
1	0.2	0.3	0.6	0.9
2	0.6	1.2	2.4	3.7
3	1.4	2.8	5.6	8.3
4	2.5	5.0	9.9	14.8
5	3.9	7.7	15.4	23.1
6	5.6	11.1	22.2	33.3
7	7.6	15.2	30.3	45.4
8	9.9	19.8	39.6	59.3
9	12.5	25.0	50.0	75.0
10	15.4	30.9	61.7	92.6
11	18.7	37.4	74.7	112.0
12	22.2	44.4	88.9	133.3
13	26.1	52.2	104.3	156.4
14	30.3	60.5	121.0	181.4
15	34.7	69.5	138.9	208.3

Note.—The correction varies directly with the slope ratio and with the square of the difference of center heights. For prismoidal less than 100 ft., multiply above corrections by the length in feet and point off two decimals.

embankment. In all calculations use the better man as the final checker, otherwise it may result in no check. Table I. will show the limits beyond which the cross-sections must be taken closer together or else the prismoidal corrections used. The prismoidal formula must be used for all masonry.

HAUL.—The positions of the mile posts are fixed, consequently when material is hauled past a post that fact and the quantity hauled must be stated in the notes on both miles affected; for instance, "On mile 50, 500 yards hauled from mile 51, and on mile 51, 500 yards hauled to mile 50." All excavated material from cuts or borrow must be estimated and paid for on the mile upon which the material is excavated. The pound of flesh method of checking to the last decimal of a yard will not be required. In figuring the overhaul, the profile of quantities method will be used, as shown by the accompanying diagram, Fig. 1.

In making this diagram, the total yardage both in cuts and fills both ways from the grade point, is summed up to the various cross-section stations within the limit of haul. These stations are then platted on a horizontal line to the scale chosen. The total yardage from the grade point to each station are then platted vertically under that station to the scale chosen and connecting lines drawn as shown. Then a horizontal scale is slid downward until it measures between the cut and fill projections 500, 600, 700 ft. These horizontal lines are then ruled in.

This diagram may be made on plate "A" profile paper or cross-section paper, to the following scales: Horizontal, 1 in. = 200 to 400 ft.; vertical, 1 in. = 200 to 2,000 yds.

In the above, the amount of solid rock is taken which will in each case, when broken to swell 60% of its volume in place, fill the yardage marked in the earth column opposite. Shrinkage and expansion affect distance hauled but not yardage hauled, this latter is always to be measured in excavation. In the diagram 1 yd. of solid rock is taken equal to 1.6 yds. in embankment, hence the dotted line is platted in proportion, vertically, thus: At the point where the regular cross-section quantities sum up to 160 yds. the dotted line passes through the 100 yd. point.

Free haul points and all other quantities taken from this diagram are to be entered in the notes as final, no further numerical calculations being necessary. The haul dia-

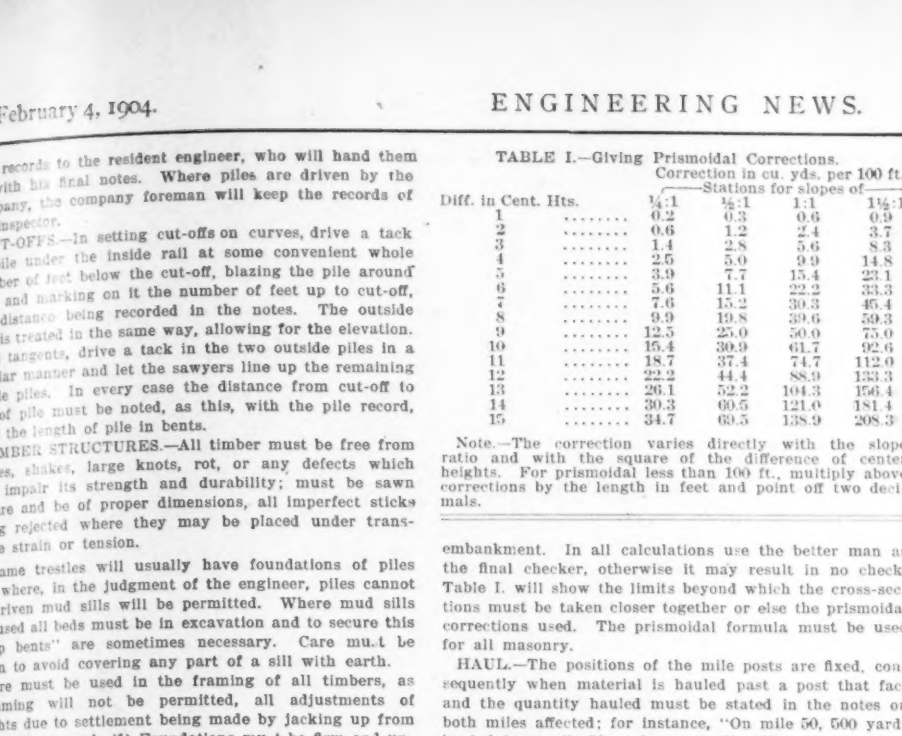

FIG. 1. HAUL DIAGRAM FOR COMPUTING OVERHAUL AND FREE HAUL.

Station.	Yds. pr Sta.	Total.
0	130	630
+50	90	500
1	120	410
+50	100	290
2	90	190
+50	60	100
3	40	40
+73	60	

Station.	Yds. pr Sta.	Total.	T'l solid rock.
3 + 73	0		
4	50	50	31
+50	30	80	50
5	50	130	81
+50	70	200	125
6	60	260	163
+50	60	320	200
7	80	400	250
+50	110	510	318
8	580	590	363
+50	120	710	444

Overhaul Eearth.
97 cy. yds. 1 station = 97
101 " " 2 stations = 202
Total overhaul to 700 ft. = 299

Overhaul Rock.
80 cu. yds. 1 station = 80
82 " " 2 stations = 164
Total overhaul to 700 ft. = 244

In the above table the amount of solid rock is taken which will, when broken to swell 60% of itself in place, fill the yardage marked in the earth column opposite.

TABLE II.—Giving Ordinates to Vertical Curves.

Distance from P. V. C.	Rate of change 0.05	0.10	0.15	0.20	0.30	Distance; rate of change from— P. C.	0.10	0.15
00	0.00	0.00	0.00	0.00	0.00	500	1.25	1.88
10	0.00	0.00	0.00	0.00	0.00	510	1.30	1.95
20	0.00	0.00	0.00	0.00	0.01	520	1.35	2.03
30	0.00	0.00	0.01	0.01	0.01	530	1.40	2.11
40	0.00	0.01	0.01	0.02	0.02	540	1.46	2.19
50	0.01	0.01	0.02	0.03	0.04	550	1.51	2.27
60	0.01	0.02	0.03	0.04	0.05	560	1.57	2.35
70	0.01	0.02	0.04	0.05	0.07	570	1.62	2.44
80	0.02	0.03	0.05	0.06	0.10	580	1.68	2.52
90	0.02	0.04	0.06	0.08	0.12	590	1.74	2.61
100	0.03	0.05	0.08	0.10	0.15	600	1.80	2.70
110	0.03	0.06	0.09	0.12	0.18	610	1.86	2.79
120	0.04	0.07	0.11	0.14	0.22	620	1.92	2.88
130	0.04	0.08	0.13	0.17	0.25	630	1.98	2.98
140	0.05	0.10	0.15	0.20	0.29	640	2.05	3.07
150	0.06	0.11	0.17	0.25	0.34	650	2.11	3.17
160	0.06	0.13	0.19	0.26	0.38	660	2.18	3.27
170	0.07	0.14	0.22	0.29	0.43	670	2.24	3.37
180	0.08	0.16	0.24	0.32	0.49	680	2.31	3.47
190	0.09	0.18	0.27	0.36	0.54	690	2.38	3.57
200	0.10	0.20	0.30	0.40	0.60	700	2.45	3.68
210	0.11	0.22	0.33	0.44	0.66	710	2.52	3.78
220	0.12	0.24	0.36	0.48	0.73	720	2.59	3.89
230	0.13	0.26	0.40	0.53	0.79	730	2.66	4.00
240	0.14	0.29	0.45	0.58	0.86	740	2.74	4.11
250	0.16	0.31	0.47	0.63	0.94	750	2.81	4.22
260	0.17	0.34	0.51	0.68	1.01	760	2.89	4.33
270	0.18	0.36	0.55	0.73	1.09	770	2.96	4.45
280	0.20	0.39	0.59	0.78	1.18	780	3.04	4.56
290	0.21	0.42	0.63	0.84	1.26	790	3.12	4.68
300	0.23	0.45	0.68	0.90	1.35	800	3.20	4.80
310	0.24	0.48	0.72	0.96	1.44	810	3.28	4.92
320	0.26	0.51	0.77	1.02	1.54	820	3.36	5.04
330	0.27	0.54	0.82	1.09	1.63	830	3.44	5.17
340	0.29	0.58	0.87	1.16	1.73	840	3.53	5.29
350	0.31	0.61	0.92	1.23	1.84	850	3.61	5.42
360	0.32	0.65	0.97	1.30	1.94	860	3.70	5.55
370	0.34	0.68	1.03	1.37	2.05	870	3.78	5.68
380	0.36	0.72	1.08	1.44	2.17	880	3.87	5.81
390	0.38	0.76	1.14	1.52	2.28	890	3.96	5.94
400	0.40	0.80	1.20	1.60	2.40	900	4.05	6.08
410	0.42	0.84	1.26	1.68	2.52	910	4.14	6.21
420	0.44	0.88	1.32	1.76	2.65	920	4.23	6.35
430	0.46	0.92	1.39	1.85	2.77	930	4.32	6.49
440	0.48	0.97	1.45	1.94	2.90	940	4.42	6.63
450	0.51	1.01	1.52	2.03	3.04	950	4.51	6.77
460	0.53	1.06	1.59	2.12	3.17	960	4.61	6.91
470	0.55	1.10	1.66	2.21	3.31	970	4.70	7.06
480	0.58	1.15	1.73	2.30	3.46	980	4.80	7.20
490	0.60	1.20	1.80	2.40	3.60	990	4.90	7.35
500	0.63	1.25	1.88	2.50	3.75	1,000	5.00	7.50

Notes.—The above table of vertical curves gives the vertical distances from the tangent grade line at the corresponding distances from the P. V. C. or P. V. T. (See first column.)

The distances are to be taken up or down, according to the form of the grade angle:

Example: Given a — 0.8 grade meeting a + 0.5 at station 103, E1.136.42.

It is required to insert a vertical curve having a rate of change of 0.1 per station.

In this case the grade angle or algebraic difference of the two rates will be 1.3 ft.

Hence the curve will be 1.3 ÷ 0.1 = 1,300 ft. long or 650 ft. on each side of the vertex,—then

103 — (6 + 50) = 96 + 50 P. V. C. El. = 136.42 + (0.8 × 650) = 141.62.

103 + (6 + 50) = 109 + 50 P. V. T. El. = 136.42 + (0.5 × 650) = 139.67.

From these elevations and that of the vertex, the elevations on the grade tangents are computed, using the 0.2 and 0.5 rates, see column 2 of the subjoined tabulation.

Column 3 gives the corrections which are taken from the vertical curve table for a 0.1 rate at the corresponding distance from the P. V. C. or P. V. T.

Column 4 in this case is the sum of columns 2 and 3, and gives the corrected grade elevations.

Intermediate values as for cut-offs, of pile bents, etc., are obtained by interpolation in the vertical curve table, before transferring to column 3 in the subjoined table.

Thus: for station 104 + 37, which is 513 ft. from the P. T., the correction would be between 1.25 and 1.30 in the proportion of 3 to 10, or 1.265.

The tangent grade at 104 + 37 = 136.92 + (37 × 0.5) = 137.105, and this plus 1.265 = 138.27. Note the sag due to the curve between 104 and 105, which are both 138.45.

Intermediate rates in the vertical curve table may be obtained by multiplying the tabular values for the 0.1 rate by the rate selected.

Station.	Tangent grade	Vertical correction.	Corrected grade.
96-50 PVC	141.62	ZERO	141.62
97	141.22	+.01	141.23
98	140.42	+.11	140.53
99	139.62	+.31	139.93
100	138.82	+.61	139.43
101	138.02	+1.01	139.03
102	136.22	+1.51	138.73
103	136.42	+2.11	138.53
104	136.92	+1.51	138.43
104-37	137.105	+1.265	138.37
105	137.42	+1.01	138.43
106	137.92	+.61	138.53
107	138.42	+.31	138.73
108	138.92	+.11	139.03
109	139.42	+.01	139.43
9-50 PVT	139.67	ZERO	139.67

grams from which the final estimates have been made are to be turned in with the cross-section notes and become a part thereof. The engineer will note expansion of rock by taking stations between which cut and fill actually balance on the ground. Haul must be estimated separately for each cut, and paid for on the section from which the excavation is made.

VERTICAL CURVES.—Vertical curves will be put in at all changes of grade where the algebraic differences exceeds 0.2 ft. and in sags the rate of change per station will not exceed 0.1. In summit cuts the rate may be increased to facilitate drainage.

To determine the length of the curve in stations, divide the algebraic difference of the intersecting grades by the desired rate, thus: If a — 0.7 grade meets a + 0.4 at station 60, the length of curve for a rate of change of 0.1 per station, would be (— 0.7 — 0.4) ÷ 0.1 = 11 stations and the curve would begin at 54 + 50 and end at 65 + 50.

To compute the correction to the regular grade elevations at any point, the following method, Fig. 2, is convenient. Let B be the point of intersection of two grades, A the point where curve commences, as above; C the end of the curve, D the point on grade A B produced below C, and E any point on curve. Compute C D from the distance C B and the grades.

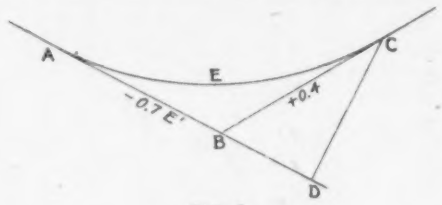

FIG. 2.

Since A E C is a parabola, the ordinates from A B vary as the squares of the distances from A, hence:

$$\frac{E E'}{C D} = \frac{\overline{A E}^2}{\overline{(A C)}^2} \text{ or } E E' = \frac{\overline{A E}^2}{\overline{(A C)}^2} \times C D,$$

whence the correction is easily computed.

For convenience, Table II. of corrections is inserted, giving the vertical distance from the tangent grade line at corresponding distances from P. V. C or P. V. T., see first column, distances to be taken up or down, according to the form of the angle. For intermediate values corrections can be interpolated from table.

REPORTS.—The engineer will compile from his diary and records on the first and fifteenth of each month, and forward to the chief engineer complete report of the progress of the work, good and bad methods of carrying on same, and any other items of importance, this being accompanied by a force report, on standard forms, giving by stations, sections and contractors the full average force at work on the line, or which might, if conditions were favorable, be at work on the line. In this, men and animals are not to be counted unless the contractor has a sufficient plant for handling them.

PROGRESS PROFILES.—Progress profiles will be sent at the end of each month to the chief engineer's office, showing graphically all material delivered and work done, and by percentages, the amount of the totals completed. The location of all bridges and size of same should be plainly marked and the depth of the lowest pile in each bent. Where track is laid or fencing done or telegraph lines put up, a line should show the end of each day's work. The marking on profiles by months should be by water colors of section lining, so arranged as to be apparent at a glance which month the work was completed in. Standard record books will be furnished for the final notes, and such notes will be written in ink when they are final, and not until then. They should comprise everything having a bearing on the final estimate and be arranged according to special instructions. A summary will be compiled at the end of each mile, showing at a glance the estimate by totals in each section, the records being kept up so far as possible while the work is in progress. As soon as the construction permits, the engineer will establish permanent bench marks every half mile, preferably on masonry bridge seats or other permanent objects; where these are not available, the engineer will call for standard bench marks, which will be furnished. As soon as the work is completed the engineer must make a final profile, showing all information required on profiles in accordance with the actual work as constructed. This profile must be made as per standard sample, on Plate "A" profile paper, continuous roll, in scale 200 ft. wide and long enough to leave 18 ins. of blank paper at each end.

To the usual title add:

Final Profile, Residency No. ——,
Miles, 18 to 27,
Stations, 1081 to 1566.

FATAL COAL MINE ACCIDENTS IN GREAT BRITAIN during 1903 were 1,032 in number, an increase of 113 over the total for 1902, and the total lives lost were 1,067. At metal mines, in the same period, there were 25 fatal accidents.

HOT-WATER HEATING SYSTEM, AND TABLE OF HEAT TRANSMISSION COEFFICIENTS.

Our report of the annual meeting of the American Society of Heating and Ventilating Engineers, in our last issue, should have been accompanied by a cut and a table, which were accidentally omitted. We give them here and trust that they may still be found useful in explanation and amplification of our report of the meeting.

The cut is a diagram sketch of the Reck system of hot-water heating with accelerated circulation, described on page 85 of our last issue. The letters on the diagram correspond to those used in the explanation of the system, on the page referred to.

The table also given herewith is taken from the paper by Mr. C. F. Hauss on "How to Figure Heating Work Accurately," and was compiled by him from German sources. The following explanatory remarks should accompany the table:

Add: 5% for rooms with unusual exposure; 10% where exposures are N., NE., E., NW. and W.; 3⅓% where the height of ceiling exceeds 13 ft.: 6⅔% where the height of ceiling exceeds 15 ft.; 10% where the height of ceiling exceeds 18 ft.

For rooms heated daily, but where heating is interrupted at night, add

$$A = \frac{0.0625\ (N - 1)\ W_1}{Z}.$$

For rooms not heated daily, add

$$B = \frac{0.1\ (8 + Z)\ W}{Z}.$$

in which two formulas the symbols have the following values:

W_1 = B.T.U. lost per hour by exposed surfaces:
W = total B.T.U. required, including ventilation or changes of air;
N = Time from cessation of heating to time of starting fire again, in hours;
Z = time necessary after fire is started until required room temperature is reached, in hours.

Heat Transmitted Through Various Kinds of Surface, in B.T.U., per H...

Cooling Surfaces	Thickness of Walls	Difference in Temperature—Fahrenheit													
		1°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	70°
Solid Brick Walls	4½″	0.48	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80	33.60
	10″	0.34	1.70	3.40	5.10	6.40	8.50	10.20	11.90	13.60	15.30	17.00	18.70	20.40	23.80
	15″	0.26	1.30	2.60	3.90	5.20	6.50	7.80	9.10	10.40	11.65	13.00	14.30	15.60	18.20
	20″	0.22	1.10	2.20	3.30	4.40	5.50	6.60	7.70	8.80	10.00	11.00	12.00	13.20	15.40
	25″	0.18	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00	9.90	10.80	12.60
	30″	0.16	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	11.20
	35″	0.14	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85	6.50	7.15	7.80	9.10
	40″	0.12	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	8.40
	45″	0.11	0.55	1.10	1.65	2.20	2.75	3.30	3.85	4.40	4.95	5.50	6.05	6.60	7.70
Solid Sandstone Walls For Limestone Walls add 10%	12″	0.45	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	31.50
	16″	0.39	1.95	3.90	5.85	7.80	9.75	11.70	13.65	15.60	17.55	19.50	21.45	23.40	27.30
	20″	0.35	1.75	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.65	17.50	19.25	21.00	24.50
	24″	0.32	1.60	3.20	4.80	6.40	8.00	9.60	11.20	12.80	14.40	16.00	17.60	19.20	22.40
	28″	0.29	1.45	2.90	4.35	5.80	7.25	8.70	10.15	11.60	13.05	14.50	15.95	17.40	20.30
	32″	0.26	1.30	2.60	3.90	5.20	6.50	7.80	9.10	10.50	11.65	13.00	14.30	15.60	18.20
	36″	0.24	1.20	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00	13.20	14.40	16.80
	40″	0.22	1.10	2.20	3.30	4.40	5.50	6.60	7.70	8.80	10.00	11.00	12.00	13.20	15.40
	44″	0.20	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	14.00
	48″	0.19	0.95	1.90	2.85	3.80	4.75	5.70	6.65	7.60	8.55	9.50	10.45	11.40	13.30
Solid Plaster Partitions.	1⅝″ 2¼″	0.60	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	42.00
	2½″ 3½″	0.45	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80	33.60
Floors	Joists with Double Floors	0.07	0.35	0.70	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20	4.90
	Stone Floor on Arches	0.20	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	14.00
	Planks laid on earth	0.16	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	11.20
	" on asphalt	0.20	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	14.00
	Arch with air space	0.09	0.45	0.90	1.35	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40	6.30
	Stones laid on earth	0.08	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.60
Ceilings	Joists with Single floors	0.10	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	7.00
	Arches with air space	0.14	0.70	1.40	2.10	2.80	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.80
Windows	Single	1.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	70.00
	Double	0.45	2.30	4.60	7.05	9.20	11.50	13.80	16.10	18.40	20.70	23.00	25.30	27.60	32.20
Skylights	Single	1.06	5.30	10.60	15.90	21.20	26.50	31.80	37.00	42.40	47.70	53.00	58.30	63.60	74.20
	Double	0.45	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.50	28.80	33.60
Doors		0.40	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	28.00
Difference in Temperature		1°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	70°

SPECIFICATIONS FOR AN ACETYLENE GAS GENERATING APPARATUS FOR FORT McPHERSON, GA.

Specifications for an acetylene plant are a novelty to so many engineers that it has seemed wise to present in full to our readers the specifications for such a plant. Bids were opened Jan. 29 for the labor and materials involved in executing the contract to be covered by these specifications; B. B. Buck, Captain and Quartermaster, 16th U. S. Infantry, being the recipient of the proposals.

Omitting the "General Conditions," the specifications follow in full:

DESCRIPTION.

The work included under these specifications consists in furnishing all material and labor necessary to construct and install in gas house at Fort McPherson, Ga., complete and ready for operation, an acetylene gas generating and storage plant, with all generating, purifying, washing, sealing, gas storing, measuring and regulating apparatus, and all gas, water and sewer connections.

NOTE.—Each bidder will submit with his proposal complete drawings and specifications for each piece of apparatus bid upon, describing the material used, method of construction and method of installing each piece of apparatus, including the internal construction and arrangement of the gas generator and tank and holder. Gas meter will be described by name and manufacturer only.

GENERATING AND CONTROLLING APPARATUS.—The gas generating and controlling apparatus will consist of an acetylene gas generator of best make, of the drop type, with carbide feed apparatus, washers and water-seals, purifiers and fire screens, drip pots, gas storage tank and holder, measuring apparatus and pressure regulator or governor, with all gas, water and drip pipe and valves necessary to connect the several parts of the apparatus and control the same.

GENERATOR.—Provide and set up in gas house, on suitable brick or concrete foundations, a generator, complete with all connections. The generator will be for acetylene gas, having a capacity of not less than 6,000 cu. ft. of cool, dry gas in three consecutive hours; will be of the drop type, where the carbide is dropped into an excess of water, and the gas, when generated, is ... through suitable piping, washer and water-... purifier and fire screen, and drip pots into a storage ... and holder of not less than 6,000 cu. ft. capacity.

The generator will be built of heavy steel plate ... than ¼-in. in thickness and fine grain cast iron; all joints between plates, and plates and cast iron will be made by well-riveted and fuller calked lap ..., and where pipes are connected to the steel shell the shell will be reinforced by cast iron flanges riveted to the shell.

The generator will be arranged with a carbide feed chamber, with carbide feeding apparatus arranged to drop any commercial size of carbide into the generating chamber at any desired speed, generating and sludge chamber will be of ample capacity to contain not less than 1 gallon of water per pound of carbide and one charge of not less than 500 lbs., and to be of the same relative capacity on any larger charge, with 2-in. water flushing inlet and 4-in. sludge discharge outlet, at least 6-in. gas outlet, air vent and overflow outlets of proper size arranged with openings so height of water can be ascertained without opening the generator or allowing gas to escape.

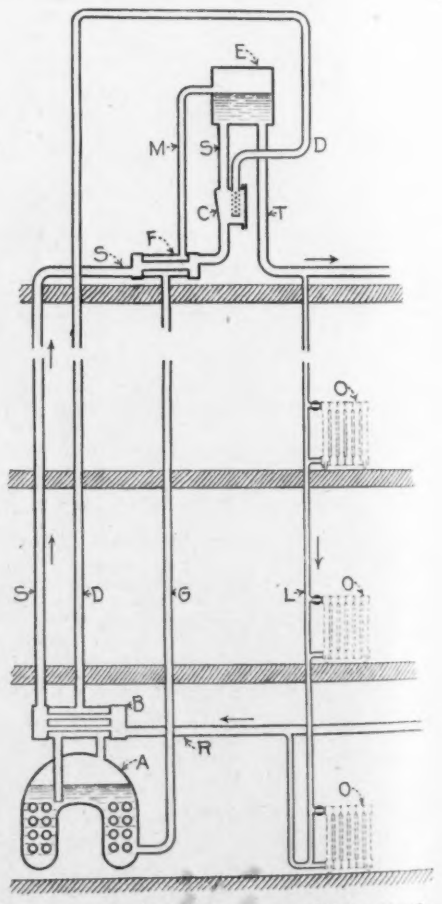

Diagram of Reck System of Hot-Water Heating.

WASHER OR WATER SEAL.—Provide and connect as near the generator as possible a gas washer and water seal of ample capacity, arranged with gas inlet and outlet pipe, gas baffle plate and water seal chamber with vent pipe. This washer and water seal will be of steel plate or cast iron of ample capacity and strength to wash and seal the flow of gas from the generator under normal working conditions.

FIRE SCREEN OR PURIFIER.—Provide and connect, between the washer and drip pot and between drip pot and governor or regulator, purifiers, arranged with alternate layers of felt and fine mesh iron screen so any small particle of lime or other solid matter will be taken out of the gas, and other fine mesh iron wire screen so arranged that in case of fire or explosion of any kind the fire cannot pass the screen into the tank and holder.

DRIP POTS.—Place below floor suitable manholes, as shown on details, one each side of gas tank and holder, and in each manhole place a cast iron or steel and cast iron drip pot, arranged with suitable gas inlet and outlet pipes and drip pipe, so any drip collected can be pumped out by connecting pump above the floor.

GOVERNOR OR REGULATOR.—Provide and connect, between the purifier and station meter on the discharge side of gas holder, a suitable sensitive regulator or governor of best make approved by the officer in charge, to regulate the pressure in the main absolutely and accurately, regardless of the pressure in the tank and holder.

STATION METER.—Provide and connect, between the governor and street mains, one standard wet gas meter of approved make, properly tested and asserted to by the Government test.

PIPE.—All connections between the different parts of the apparatus to be made with new wrought iron (not steel) pipe, and for street mains to 5 ft. outside of building of the best quality, standard sizes and weights; all over 1¼-in. to be lapwelded, the bur or fin in the end of the pipe, or any other obstruction, to be removed before putting pipe in place. The size of all gas pipe will be as shown on plans. Vent pipes to be carried to a point 5 ft. above the roof as directed. A 2-in. water pipe to be connected into post water main where directed, by means of a water connection of best make approved by the officer in charge, with four ¾-in. branches, and carried in suitable trench, not less than 2 ft. 6 ins. deep, satisfactory to the officer in charge, into building, where branches of proper size will be taken off to supply the several parts of the apparatus and to a 2-in. gate valve properly threaded, similar to the threads on the fire hydrants at the post, to take a standard 2-in. fire hose coupling.

Before entering the building connect in this water line a 2-in. stop and waste of best make, set in a cast iron box brought to the surface of the ground with solid cover marked "Water," and a long-handled key. Surround the bottom of this box by at least ½ cu. yd. of broken stone of a hard nature, no piece of which to be larger than a 2-in. cube.

All pipe in building to be so graded that closing waste outside of building will drain all pipes dry.

FITTINGS.—All fittings to be of standard size and weight, of fine grain cast iron, free from holes and spongy spots, with clean cut taper threads. Where pipe changes size proper reducing fittings will be used (no bushing will be allowed). Where necessary eccentric fittings will be used to provide unobstructed flow of condensation and drain pipes dry.

VALVES.—All valves will be straight way gate valves, of best make approved by the officer in charge, Eddy or equal, with double-seated gate, external yoke and screw; all to have cast brass gate and brass stem; those for water to be brass throughout.

TANK AND HOLDER.—Provide, erect and connect a suitable one-lift steel gas storage tank and holder. Holder to have a diameter not less than 24 or more than 26 ft, with flat crown or head, well framed and braced; holder to have a capacity of not less than 6,000 cu. ft. of gas when inflated and give a pressure of approximately 4 ins. of water. Tank to be not less than ¼-in. steel plate of suitable size for the above holder, giving a water seal of not less than 12 ins. when inflated. Tank and holder to be built of mild steel having a tensile strength of not less than 60,000 lbs. per sq. in. of section, and an elongation of from 20 to 25% in a section 8 ins. long.

CURBS.—The tops and bottoms of tank and holder, each to be fitted with suitable angle trancurbing not smaller than 3 × 3 × ⅜-in. angle vertical legs. The holder to be fitted with at least vertical legs of 3½ × 3½ × ⅜-in. angles, properly secured to the holder.

CARRIAGES AND ROLLERS.—The holder to be fitted with at least 12 suitable carriages and cast iron rollers; four fastened to the crown and eight to the bottom curb of holder; all to work against the guide rails of frame and tank.

GUIDE FRAMES.—The guide frame to consist of not less than four standards of 4-in. rails, weighing 18 lbs. per ft., properly secured to the tank and held at the top by four suitable double struts consisting of two angles not less than 4 × 3 × ⅜-in. and braced from the top curb of tank by not less than 8 angle braces of 2½ × 2½ × 5-16-in. angles, two to each standard extending from the top curb of tank to standard at proper point.

TANK RAILS.—The tank to be fitted with not less than 8 guide rails of 4-in., 18 lbs. per ft. rails, fastened securely to the tank.

LANDING BLOCKS.—The tank to be fitted with at least 8 cast iron landing blocks, one for each vertical leg, secured to bottom of tank to support the holder when it is resting in tank.

OVERFLOWS.—The tank will be fitted with suitable 2-in. overflow.

INLET AND OUTLET PIPES.—Furnish and connect 8-in. inlet and 8-in. outlet pipes, one each with fittings complete, from drip pots in manholes into gas holder.

JOINTS.—All joints between steel sheets and steel sheets and angles or castings to be made by well-riveted lap-joints, all joints to be made tight by fuller calking. No split tool calking will be allowed.

PAINTING.—All iron work, including piping, to receive two coats of Dixon's Silica Graphite paint, one coat before and one after erection, except the generator, tank and holder, which will receive both coats, both inside and out, after erection.

FOUNDATIONS.—Each piece of apparatus to rest on suitable foundations of concrete composed of 1 part best Portland cement, of a brand approved by the officer in charge, 2 parts clean, sharp sand and 4 parts of broken stone or coarse gravel of a hard nature, no piece of which to be larger than a 2-in. cube.

Foundations to be of size and shape as required by the several parts of the apparatus and the nature of the ground, and of such depth as to provide absolute security against insecure foundations.

FLOOR DRAINS.—Provide and properly set in concrete floor where directed, three 10-in. diam. combination floor drains and traps, of best make, with 3-in. outlets; drains from traps to be 3-in. extra heavy cast iron pipe carried to a point about 5 ft. outside of building and there connected into a 6-in. salt-glazed, hub-joint vitrified terra cotta pipe drain carried to an outlet where directed by the officer in charge, the outlet above ground to be protected by a wrought iron grating set in a brick heading with a stone cap, all laid in cement, no connection to be made with sewer.

Furnish and lay 6-in. hub-joint salt-glazed, vitrified terra cotta pipe from the 2-in. stop and waste outside of building and connect same into 6-in. drain from floor drain.

All terra cotta pipe to be laid in neat Portland cement joints to a true grade not less than one-quarter inch to the foot, with hubs sunk below general level of trench to admit of solid bearing for pipes.

EXCAVATING.—Excavate trenches for all water, gas, and drain pipes as directed by the officer in charge, to a depth of not less than 2 ft. 6 ins. or such additional depth as may be required to obtain the desired grade to pipes, and fill all trenches after pipe is laid; also excavate as required for all foundations.

SLUDGE DRAIN.—Properly form in concrete floor under sludge discharge opening of generator a suitable opening to receive the sludge discharged from the generator and all drips from parts of the generator, this opening to be connected into the tank for residuum with an 8-in. hub-joint salt-glazed, vitrified terra cotta pipe as specified for drain pipe, and laid in a similar manner; all pipes discharging into this opening will be so arranged that any leaking can be detected.

Furnish one pump of approved make for pumping drip from drip pots, also one 50-ft. length of fire hose similar to the fire hose already in use at the post.

THE NEW ORDINANCE FOR FIRE PROTECTION OF THEATERS IN CHICAGO.

After the Iroquois theater fire, the city council of Chicago undertook to revise and systematize the various principal ordinances relating to the theaters, and a special committee was appointed to investigate the matter. The committee heard a great deal of evidence and obtained expert advice, and on Jan. 25 the council passed a new ordinance, which will require extensive alterations and improvement to be made in nearly every theater in Chicago. The requirements governing the reopening of the theaters are as follows:

Ordered, by the city council of the city of Chicago, that all persons, firms, and corporations, owning and operating theaters in the city of Chicago, who will agree to make such alterations or changes as are necessary to comply with the building ordinance passed on Jan. 18, 1904, said alterations and changes to be made not later than Sept. 1, 1904, shall be permitted to open and operate their theaters, or such part of said theaters as an investigation will show can be operated in compliance with the said ordinances and amendment thereto. Provided, however, that before being permitted to open any such theaters the owners or lessees thereof shall first comply with the said ordinance in the following particulars:

1. They shall have a brick proscenium wall and a substantial vertically operated steel curtain, fireproofed on the stage side thereof, which curtain shall be in constant use as the regular curtain and act drop as provided in the ordinance.
2. They shall install or erect one or more vents or flue pipes to be placed in the roof over the stage.
3. They shall install all fire apparatus and fire alarm equipment provided for in the ordinance.
4. They shall employ two or more firemen.
5. They shall fireproof all scenery and stage settings with fireproof paint or other approved fireproof solution.
6. No theater shall be permitted to open unless, in the judgment of the mayor, commissioner of buildings, and the special committee on reopening of theaters, the entrances, exits, stairways, and aisles of such theater are sufficient to render said theater safe.
7. They shall comply with such additional requirements, restrictions, and conditions as may be imposed by the mayor, commissioner of buildings, and said special committee, and provided further that the said additional requirements, restrictions, terms, and conditions be reported to the city council.
8. Before any theater is opened under this resolution every part of the building shall be thoroughly cleaned. All surplus material of combustible nature shall be removed from rooms beneath the stage, from the fly galleries, from mechanics' rooms and dressing rooms. No part of the building shall be used for storage purposes, and all property not in actual use shall be stored outside the theater building. All air ducts leading to the auditorium or stage shall be thoroughly cleaned out.

Be it further ordered, that before any theater shall be opened under the terms and conditions of this order the owners or lessees thereof shall execuhte unto the city of Chicago a good and sufficient bond in the penal sum of $25,000, conditioned that such owners or lessees shall faithfully observe and perform each and every condition and requirement of the said ordinance of Jan. 18, 1904, within the time fixed in said order. Said bond shall be in form to be approved by the corporation counsel and the sureties thereon shall be approved by the mayor.

THE REPORT OF THE BUREAU OF NAVIGATION shows that 62 vessels of 23,358 gross tons were built in the U. S. during the month of December, 1903, and that 571 sail and steam vessels of 177,067 gross tons were built and numbered during the six months ending Dec. 31, 1903; and that the total number of vessels built and numbered in the U. S. in 1903 was 1,159, of 381,970 gross tons, as compared with 1,262 vessels of 429,327 gross tons in 1902, and 1,322 vessels of 376,129 gross tons in 1901.

THE NUMBER OF VESSELS LAUNCHED all over the world during the year of 1903 was 2,441, with a tonnage of 2,679,531, according to the Glasgow "Herald's" annual review. The output of the yards of Great Britain compared with the U. S. and Germany is given as follows:

	Vessels.	Tons.	I. H. P.
United States	188	493,144	324,290
The Clyde	277	446,869	455,221
The Tyne	149	262,794	254,405
Germany	271	261,003	197,225
The Wear	60	189,339	137,465
Tees and Hartlepools	67	171,304	89,640

Great Britain produced about 52% of the total tonnage built in the world during 1903.

A DECISION AS TO THE FELICIDAD ASPHALT mine ownership has been rendered by the Federal High Court, sitting at Caracas. This "mine" was bought in 1898 by Warner & Quinlan, of Syracuse, N. Y., from the Bermudez Asphalt Co., but the court gives as its unanimous judgment that their title is null and void.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Missouri Pacific Ry. near Miller, Kan., on Jan. 31. An eastbound through passenger train, bound for Kansas City from Denver, was derailed while running at high speed. One person was killed in the wreck.

AN ELEVATOR FALL which occurred in the building 74 Broadway, New York City, on Feb. 2, is interesting because the elevator is of the differential or running-rope type; in this type there are two motors geared to the endless elevator rope in such a manner that when both motors are running at equal speed the elevator remains at rest, and its speed at any time equals the difference in speed of the two motors. It is said that this was the only running-rope elevator in New York City. The man in charge of the car had been in that position only a few days. There is some evidence to indicate that the operating machinery of the elevator was out of order, but no conclusive information is yet obtainable.

A SERIOUS EPIDEMIC OF TYPHOID FEVER is in progress at Columbus, O. From 40 cases for the month of December, the January record mounted to 705 cases for the first 30 days of the month, with 81 cases on Saturday, Jan. 30. The cause of the outbreak is believed to be the pollution of the public water supply. Mr. F. H. Eno, Assistant Professor of Civil Engineering at the Ohio State University, Columbus, O., has been engaged by this journal to report on the outbreak. His report will appear in our issue of Feb. 12.

THE WORK OF DREDGING SAN PABLO BAY, California, has been suspended by Chief Engineer Hener on the ground that the contractor, Rudolph Axman, has failed to make satisfactory progress. The contractor has appealed to the Secretary of War for an extension of time, on the ground that the Government charts misrepresented the depth of the water, it being shoaler than was shown, and that in consequence there was a partial suspension of work at low tide, owing to inability to dump the scow along the shore at low tide.

A NEW PATENT LAW, has been enacted in Mexico, which will make the exploiting of new inventions in that country much easier than it has been in the past. The text of the new law is printed in full in the Consular Reports for January, copies of which can be procured from the Department of Commerce and Labor, Washington. The new law requires application to be filed within three months after the issue of a prior foreign patent. Examination is for form only. The term of the patent is to be twenty years, and a tax of $5 is enacted for the first year and of $35 for the remaining nineteen years. An extension of five years may be granted. Working the patent is not obligatory; but in case it is not worked compulsory licenses may be obtained.

The new law is to take effect on Oct. 1, 1904. Patents already issued will be governed by laws previously in force, but may be brought under the provisions of the new law if application is made within six months from Oct. 1.

HIGH-SPEED EXPRESS TRAINS are proposed, in Germany, according to an item in "The Engineer" from which we quote as follows:

The Prussian Railway Ministry contemplates shortly making a series of interesting experiments, with a view to running express trains from Frankfürt to Hamburg, via Marburg, Göttingen, and Hanover, at the rate of 68 miles an hour. Preparations on this line, which is 340 miles long, have already been effected. Iron sleepers have been substituted for those of wood, and the underlying bed has been composed of broken stone and gravel, while steel rails have taken the place of iron. Trial trips were recently made on the line, thus strengthened between Marburg and Frankfürt, with ordinary engines, and a speed of 55 miles an hour was easily attained. According to the Berlin correspondent of the Daily Telegraph, special engines with four cylinders are being provided, which will, it is anticipated, increase the velocity to 62 or 68 miles an hour.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication: new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday at 10 a. m.

It is so rare an occurrence for an outside engineer to report in favor of the installation of a meter system rather than the acquisition of a larger water supply that we call particular attention to a recent report to the city of London, Ont., made by Mr. Willis Chipman, M. Am. Soc. C. E., of Toronto, Ont. Mr. Chipman estimates that by placing meters on 75 per cent. of the services the present supply could be as good as increased by 25 per cent. An alternative would be to construct an independent service for fire and business purposes in the center of the city, and still another possibility is to build a pumping and filtration plant above the city. Any of the three plans would involve new and larger mains and the first cost and yearly expense under each plan would be about the same. About 6,500 meters would be required under the plan recommended, the placing of which could be distributed through some five years. Perhaps the conditions at London are exceptional, but is it not more probable that the construction of works for an additional supply is more attractive to most engineers than the idea of installing meters, and that this accounts for the rarity of such recommendations as we have just noticed?

It has long been the practice of railway companies not to publicly advertise for bids for construction contracts unless the work is of great magnitude or of special character. The strongest argument in favor of this practice has been that by inviting bids from a selected list of experienced contracting firms the contract would be awarded to a firm whose ability had been demonstrated.

This argument has gone for so long a time unchallenged by counter arguments that the practice of private letting has become part of the railway official's creed, scarcely to be questioned. There are, however, we believe, better economic reasons for the public letting of railway contracts than is commonly supposed. At this time we would call attention to just one argument in favor of the public letting of railway contracts. In the railway news of last week will be found an item relative to alleged collusion among certain contractors who submitted bids for the tearing down of buildings on the site of the proposed Pennsylvania Railroad station in New York City. It appears that eight of the competing (?) firms have secured an injunction against the contractors who are tearing down the buildings, on the ground that they have not shared the profits as agreed upon before bidding. Surely there is food for thought in this incident, and unfortunately it points to a condition of affairs often existing but seldom disclosed.

Where a given number of contracting firms realize that competition is limited to them they would be strangely behind the times in these days of "combination" if they did not come to some understanding among themselves as to the division of the work or the profits. Wrapped up with the question of ethics in such transactions is the question of economy. The railway whose construction work is done by one or more cliques of contractors is certainly paying a high premium for securing "responsible" contractors. It would seem that while public advertising and letting of railway contracts might occasionally result in the award of a contract to an irresponsible firm, the saving in cost on the bulk of contract work would offset any occasional smaller loss arising from delay. But if railways were to require the bonds of a surety company, and if in addition a record of the work done for other railways by each contracting firm were looked into, there is not the slightest doubt that the average of responsibility among successful contractors would be quite as high as at present; and, in addition, there would be real competition where now there is only a pretence in many instances.

The Canadian Government has appointed a special commission to investigate the various processes of direct reduction of iron from its ores by use of the electric current. The members of the commission sailed for Europe on Jan 28 and expect to spend several months abroad.

An esteemed contemporary, in commenting on the appointment of this commission, wisely remarks that its report will probably serve a useful purpose by pointing out the limitations of the electric process and warning the public, which is in danger of being misled by the claims of promoters of electric reduction processes who are selling stock in their enterprises.

In this connection we note with interest an elaborate paper on "The Electric Smelting of Iron and Steel" in the "Iron and Coal Trades Review" of Jan. 15. The various smelting processes of Stassano, Heroult, Keller, Harmet, Schneider, and others, are described and their claims are set forth, after which our contemporary reaches the following conclusions:

> The conclusions, therefore, which follow from an investigation into the electric methods of smelting steel are that the conditions under which the actual manufacture of iron and steel may be profitably carried on by electric methods are so rare that they may be said practically to be non-existent. M. Heroult himself admits that he has for the present laid aside his process for making metal in favor of processes whereby he produces tool steel. With this latter high-priced product no one will deny that there may be a future for electrical processes. So far as ordinary smelting is concerned, in "Engineering News" of May 2, 1901, in an able article, it was shown that assuming no loss of heat energy whatever and a theoretically perfect furnace, it would require 131 e.h.p. days (of 24 hours each) to produce a net ton of iron from a 65% ore.

Our contemporary has rightly interpreted our position. What we attempted to demonstrate in our editorial of May 2, 1901, was the practical impossibility of the electrical furnace competing with the blast furnace as a means of reducing iron in bulk from its ores; or in other words, to make a product to compete with pig iron selling for from $8 to $20 per ton.

If, however, an electric furnace can be made to produce a material which can compete with tool steel or crucible steel, or any of the higher grades of steel, worth, say 5 cts. per pound and upward, then it will have a chance of commercial success where conditions favor its use.

What these conditions are, it is easy to see. The first requisite is a cheap source of power, preferably water power, which may be economically transformed into electric energy. The second requisite is a supply of ore of a high degree of purity. The third item is a fairly cheap supply of pure carbon, such as charcoal, for reducing the metal from its oxide, for while the electric current can supply the necessary heat, the presence of carbon is also necessary to overcome the attraction of the oxygen for the iron.

Besides this, it will be evident that any such process will have best chance of success in a region remote from the centers of iron production, where a local market for the production can be secured, with the advantage that competing material will be subject to a heavy charge for freight.

It will be noted that in the quotation above from our English contemporary, it is stated that Heroult has abandoned for the present his electrical ore reduction process for a process whereby he makes tool steel from raw materials consisting of pig iron and scrap, or similar raw materials to those used in the open hearth furnace. The process of Kjelling, a Swedish engineer, also described by our contemporary, produces crucible steel in an electric furnace from raw materials consisting of charcoal, pig iron and soft wrought iron.

These processes are said to be commercially successful, and we see no reason why they should not be. They are not, properly speaking, smelting processes or ore reduction processes at all. They are merely means for applying the heat obtained from an electric current to the melting of a quantity of iron or steel and other substances used as a flux or otherwise. This requires an amount of heat which is trifling compared with the amount required to reduce the same metal from its oxide, and there is no reason, therefore, why the electric heating might not prove a success. That the electric process would have the advantage of securing heat without the risk of adding hurtful ingredients to the metal, such as sulphur, will, of course, be evident. Whether this advantage is offset by other disadvantages, it must be left for experience to develop.

Popular misconceptions of the methods to be adopted to prevent the spread of typhoid fever where epidemics of that disease prevail are well illustrated by an editorial article in the Leadville (Colo.) "Herald" of Jan. 12. The article has the strongly suggestive and very appropriate heading, DISINFECT; but the objects of disinfection are "drains, outhouses and other disease breeding places," and the "gutters and alleys" of the city, while the disinfectant advised is chloride of lime. Not a word is said as to the vital necessity of disinfection of the fæces and urine of the typhoid patients before they are removed from the sick room. Filth in the abstract is made a fetish; specific personal infection is ignored. Possibly we are doing the "Herald" some injustice, since in a previous number it may have urged disinfection in the sick room. Possibly, also, it has advocated other preventive measures by the city government than buying a wagon load, or even ten tons of disinfectants and distributing them broadcast. Certainly it is to be hoped that it has advocated the most thorough control of the water and milk supplies and a thorough system of reporting all cases of typhoid fever and placing the same under efficient sanitary supervision. It may be noted here that in a letter from Dr. Soper, published in our issue of Jan. 28, he stated that chlorinated lime is too volatile for effective use and that he suggested milk of lime, bichloride of mercury and formaldehyde as disinfectants. The milk of lime, we take it, would be for use on a large scale; the bichloride of mercury for the dejecta of single patients, and the formaldehyde for the general disinfection of rooms and their contents. Finally, the Leadville "Herald" is to be commended for advising thorough-going private and public action to prevent the spread of typhoid fever, and it is not one whit behind the common conception of press and public as to what that action should be: All of which illustrates the urgent need for more general education in the elements of public sanitation.

The lack of a system of registering vital statistics in three-fourths of the states of the Union is in no small degree a contributing cause to both epidemic and endemic typhoid fever and other communicable diseases, and is in many other ways a hindrance to sanitary progress. At the time of taking the last National Census there were only ten registration states, including the District of Columbia; that is, states whose vital statistics were sufficiently reliable to warrant their acceptance by the Census Office. In addition, there were

153 registration cities in non-registration states. The registration states were, with one exception, all in the northeastern part of the country. They included the six New England states, New York, New Jersey, the District of Columbia and Michigan, with a combined population of 17,444,280. The 153 registration cities in other states had a total population of 11,363,989, making a grand total of 28,807,269 out of the 76,000,000 inhabitants. Since the year 1900 Indiana and Colorado, according to the "Monthly Bulletin of Vital Statistics" of Michigan, have passed good registration laws. There has been some legislation in Illinois, but how good the "Bulletin" does not say. An immediate effort is to be made, the "Bulletin" adds, to secure legislation in all the non-registration states whose legislatures hold sessions this winter, including Iowa, Kentucky, Maryland, Mississippi, Ohio, South Carolina and Virginia. Some of these states already have laws for the collection of vital statistics, but the systems in vogue are inadequate. Thus, the great state of Ohio, with a population in 1890 of 3,672,316, merely requires, outside of certain cities, tax assessors to obtain annually the births and deaths for the year ending March 31 and to report them to the judges of county probate courts (about 90) for record, compilation and abstract. The enumerations, for the most part, are thus made months after the occurrence of the births and deaths; and both enumerations and compilations are made by men with no special qualifications for or interest in their task. Under such circumstances the statistics are necessarily incomplete and inaccurate, besides serving no purpose whatever in the way of warnings against insanitary conditions, as reflected in the deaths from communicable diseases. Aside from health officials, no class of men could more effectively use morbidity and mortality statistics, particularly those relating to communicable diseases, than could municipal and sanitary engineers, but such statistics should be accurate, well classified and promptly available. Engineers of all classes might very properly take a hand in extending the registration area to those states which are still without a pretence of adequate vital statistics, while throughout most of the registration area they might well use their influence to secure greater accuracy and promptness in the returns of communicable diseases.

ESTIMATING THE VOLUME OF RAILWAY TRAFFIC.

In the great bulk of the railway construction which has been done in this country, it has very seldom happened that the engineer has been called on to estimate what a railway would earn when completed. His sole duty has been to lay out the line and supervise the construction. The promoters and financiers who have employed him have seldom cared for estimates of traffic. Often they have been chiefly concerned in making a profit in the construction, unloading the property afterward on some one else. Again a large part of the railway mileage in the West has been built in advance of the traffic and even of population. Those who built the lines had faith that the country would furnish resources to support them, and this faith has generally been justified in the end, although not seldom a receivership or two has occurred before the lines became paying enterprises.

There is good evidence, however, that the day of speculative railroad construction is largely past. The promoters of a railway project at the present time frequently expect from their engineer not only an approximate estimate of what the line will cost to construct, but also an estimate of what traffic it can command when completed. An example of this is furnished in a letter recently received, from which we quote as follows:

Sir: As engineers reporting on proposed railway lines, we are usually required to estimate the probable volume of traffic. I think Wellington in his "Economic Railway Location" estimated the total revenue roughly at $13 per head of population per annum.

Omitting mineral traffic, could not the cities and towns be classified; and then the farming community, in proportion to the population? I do not suppose it would be some simple addition in the case of cities, but some factor by which the number of people served, would have to be added to their totals. Any reasonable approximation would be very valuable information, and the question nearly always arises away from cities among farming communities. C. S. Y.

Baltimore, Md., Jan. 28, 1904.

The above letter led to a search through engineering literature to see what data were available on this subject. Wellington, in his treatise, devoted an entire chapter to methods of estimating the probable volume of traffic and much of what he said is as applicable to present conditions as when it was written. His tables and figures, however, are compiled from the railroads of 20 years ago, and not those of the present; and this fact must always be borne in mind by the user of his book.

At the time Wellington's book was written,(about 1885) the average gross earnings of all the railways of the United States per capita of population per annum were about $13.50, of which $10 was for freight transportation and $3.50 for passenger transportation. This, doubtless, is where our correspondent obtained his figure of $13 per capita.

These figures, however, are wholly out of date at the present day. Taking the earnings of all the railways in the United States for the fiscal year 1902 from the last issue of "Poor's Manual," and dividing by the total population in that year (obtaining by adding 3,000,000 to the census figures for 1900), we have a total of $21.80 in round numbers, as the average contribution paid by each man, woman and child in the country for railway transportation.*

Of course it is to be borne in mind that these figures represent a period of abounding prosperity, when American railway lines were crowded with traffic as they have never been before, and when traffic rates were well maintained. The fluctuation in railway earnings per capita of population during the twelve years from 1888 to 1900, is shown in a table given in Webb's recent treatise on "Railroad Construction," from which we take the following:

Year.	Population; (estimated for other than census years).	Receipts. Gross.	Receipts. Per head of population.
1888.....	60,100,000	$910,621,220	$15.15
1889.....	61,450,000	964,816,129	15.81
1890.....	62,801,571	1,051,877,632	16.75
1891.....	64,150,000	1,096,761,395	17.10
1892.....	65,500,000	1,171,407,343	17.89
1893.....	68,850,000	1,220,751,874	18.26
1894.....	68,200,000	1,073,361,797	15.74
1895.....	69,550,000	1,075,371,462	15.46
1896.....	70,900,000	1,150,169,376	16.22
1897.....	72,350,000	1,122,089,773	15.53
1898.....	73,600,000	1,247,325,621	16.95
1899.....	74,950,000	1,313,610,118	17.53
1900.....	76,295,220	1,480,673,054	19.41

If the figures of this table be brought down to the year 1902, the latest for which returns of railway gross earnings are now available, we have, as stated above, average receipts per head of population amounting to $21.80.

And now arises the question: to what extent can these figures be made a practical guide in estimating the probable traffic of a proposed railway? It seems to us the answer must be: "to an exceedingly limited extent if at all."

These figures show simply that the "mean" inhabitant of the United States paid in 1902 for the transportation of himself and all the articles which he used,—food, clothing, fuel, etc.,— and for his share of the transportation required by all the industrial operations necessary to production, the sum of $21.80. Where shall one look, however, to find the residence of the "mean" inhabitant? On the one hand we have the residents of the wealthy cities of the East drawing their food supplies from regions one to two thousand miles away, and their supplies of raw material—iron, coal, cotton, etc.—for use in their industries, from a distance quite as great. At the other extreme we have the residents of the Southern mountains, producing little or nothing to send to other sections of the country and accustomed for generations to life in self-supporting communities which raise from the soil practically all they require. In these latter communities, indeed, traffic in proportion to population falls to the lowest point. Wellington found in 1885 that the gross revenue of the railways of the South Atlantic States per head of population served was only $5.07, and in the state of Florida the rate fell to $1.60.

*This does not include the traffic on electric railways, which are now carrying a large proportion of the suburban and interurban passenger traffic that was carried on steam railways twenty years ago.

Let us suppose, however, for the sake of argument, that in the laying out of a certain branch line of railway whose probable traffic it is desired to estimate, the fact is established that the inhabitants are fairly representative of the average for the whole United States. Can we then make any use of this average rate of revenue in estimating the future traffic? To put the matter in plainer form, suppose we are estimating the traffic of a proposed 20-mile branch line which will have a population tributary to it of some 10,000 persons. Could $21.80 × 10,000 = $218,000 be assumed as a possible future annual revenue? By no means, for the food and fuel and other supplied brought to these 10,000 people, and their products taken away in exchange are carried not merely over the 20-mile branch line whose traffic we are trying to estimate, but over perhaps five hundred or a thousand miles of connecting railways. The great bulk of this contribution of $218,000 from these people will go, therefore, to the main line railways and only a small part to the local branch road.

It is evident, then, that figures of average traffic per capita cannot be used to estimate probable volume of traffic; first, because we cannot estimate, save in the most general way, what average traffic payments the population along the line will yield; and, second, because even if we knew this we could not tell what division of the sum might be made between the branch railway and its main line connections.

We do not find, on examination of the authorities, that estimating revenue directly from population served has been advocated by writers on railway location. Wellington gave, it is true, voluminous tables of figures upon this point; but he gave them chiefly as data for estimating the rate of growth of railway traffic; and he distinctly recommended that estimates of probable future traffic be based on "the probable number of trains a day." Webb, in his recent treatise on "Railroad Construction," says that estimates based on average traffic produced per head of tributary population are unreliable and only valuable as a rough check on other methods.

The method which Webb recommends is an actual study of the route and a determination of the probable output of factories, mines, etc., along it. Added to this would be an estimate of the amount of farm produce and lumber which might be fairly counted on, and an estimate of the passenger traffic based upon figures from some existing railway operating in a similar region.

We may add that the above estimate relates chiefly to the outgoing traffic and that something may be added for the merchandise traffic, fuel, etc., shipped inward, and for this purpose figures of the population served might be a helpful guide.

There is another matter which must be borne in mind in investigating the question of the revenue a proposed road can secure. It is the rate which the traffic will bear.

One of the commonest and very best ways of forming an opinion whether a given road will pay or not, is to examine the revenues of some other road in a similar locality, serving a similar class of population. In making such a comparison, however, the rates charged must not be overlooked. There are branch line railways in the United States which charge an average freight rate per ton-mile as high as 5 cts. or 10 cts., and even up to 20 to 30 cts.; and in most cases these companies are obliged to charge such high rates in order to pay their operating expenses.

In reporting on a railway project, therefore, it is important not only to consider the probable volume of traffic, but also what rate can well be maintained upon that traffic without driving it to some other means of transportation or so hampering industries as to check and limit their growth.

In concluding this brief review, a word may not be amiss as to whether such work as the estimation of traffic, of revenue, of expenses and of final net earnings belongs after all to the engineer. It is sometimes said that this is commerce or eco-

nomics and not engineering. We maintain, on the contrary, that it is actually engineering work of the highest class, and, we may add, the most remunerative. It belongs, we maintain, to the engineering profession because the members of that profession, if they have the breadth of mind and judicial training that they should have, can perform it better than anyone else.

To make the work of the engineer merely that of a skilled measurer and an expert judge of materials, is to degrade the profession to mere computers and testers. The largest rewards of the profession are reserved for those whose grasp of affairs is such that they can deal with the intricate problems of economics and industry and foresee the safety or the danger of new fields for investment offered to capital.

LETTERS TO THE EDITOR.

The Results of a Break in a Canal Embankment.

Sir: Upon looking over some old notes recently, I found a photograph of a break in the Erie Canal which may be of interest to illustrate the dangers, both physical and financial, attending navigation upon the Erie Canal.

A BREAK IN THE ERIE CANAL AND ITS RESULTS.

The break occurred near Hoffman's Ferry, June 5, 1895, and was described in the "Transactions of the Association of Civil Engineers of Cornell University," Vol. IV. The picture has not been published, to my knowledge, and though the event happened several years ago it will be a novel sight for many of your readers.

Yours truly, Albert J Himes.

521 Hicks Building, Cleveland, O., Jan. 4, 1904.

Removing Ice from Railway Tracks with a Steam Shovel.

Sir: A somewhat novel use of a steam shovel has been made this week at Conneaut Harbor, Ohio. During the thaw and consequent freshet of the Conneaut Creek, last week, the yards of the Bessemer & Lake Erie R. R. and the Pittsburg & Conneaut Dock Co. were flooded and covered with floating ice. When the water had receded to normal in the creek, a large part of these yards was left covered with cakes of ice piled to a height as great as 4 or 5 ft. in many places. This condition entirely prevented the movement of any trains in or out from the yards; consequently stopping the shipment of any iron ore. In order to get a through track cleared quickly, one of the Dock Company's steam shovels was started in and made a cut through the ice wide enough to let an engine through. The ice thus removed was simply thrown to one side of the track. This method was found to be very fast and economical, inasmuch as this one shovel with the operators and four men on the ground cleared nearly a much track in one day as 50 men working with picks and shovels. After getting one track clear, another shovel was started on the track next to it, making a second cut and throwing the ice still further to one side. Thus, by working two shovels one ahead of the other and on two tracks next to each other, the ice was removed quite fast and cheaply. Yours very truly, Gordon S. Meek,

Civil Engineer for P. & C. Dock Co.

Conneaut, Ohio, Jan. 28, 1904.

The Use of Marking Rods to Mark the Position of Sewer Branches.

Sir: In your issues of Dec. 31 and Jan. 14 reference was made to the use of studs for marking the location of branches left in sewers. The writer's sewer specifications contain this clause:

MARKING RODS.—1 × 2-in. marking rods will be placed at each branch and shall extend vertically from the sewer to the street surface. The top four feet of these markers shall be creosoted material. The price of these markers shall be included in the price bid for branches.

In practice these markers are made to extend a few inches above the surface of the street, and the creosoted material is simply tacked to an inexpensive lath below. The upper portion of these markers will rot out more quickly than the lower portion because more subject to alternate wet and dry conditions, hence the advantage of using creosoted stock; the preservation of the upper four feet is all that is required. Besides affording an easy method of locating the branches without digging down to the sewer, the temporary advantage of this practice is to enable the engineer to check the record of the branches even after the sewer is covered up. The exposed part of the markers can be driven flush with the street surface after the backfilling has been properly completed. The markers cost 6 cts. each, a trifling addition to the cost of the sewer. Very truly, Alexander Potter.

143 Liberty St., New York City, Jan. 22, 1904.

A Rule for Dropping Decimal Places.

Sir: At a recent meeting of engineers in this city the following rule for dropping redundant places of decimals in computations was discussed: "If the last figure is 5, discard it, and make the preceding figure, which is to be retained, even." For example, if you have 2.75 and 2.65 and wish to express the two quantities to tenths, either for convenience or because the last place is hardly justified, the first one by the above rule becomes 2.8 and the second one 2.6. This rule is to be used in conjunction with the usual rules: If the discarded figure is greater than 5 increase the preceding figure by one, and if the discarded figure is less than 5 simply drop it. These two latter "rules" can hardly be called rules, for what they prescribe is evidently the only course to follow.

In discussing the subject the following rule was thought by some to be easier to use and "accurate enough":

When the quantity ends in 5 drop the 5 and increase the preceding figure by one.

By this method, in the above example, the first of the quantities becomes 2.8 and the second 2.7, their sum being 5.5, whereas by the first rule mentioned their sum is 5.4, the same as obtained by retaining the hundredths.

The question is brought to your consideration with the desire of having it placed in your correspondence columns to ascertain the practice of engineers in general.

Yours truly, A. H. Horton.

1233 12th St., N. W., Washington, D. C., Jan 18 1904.

The Grand Forks Typhoid Epidemic of 1893-4.

Sir: Regarding some of the questions raised by Dr. Soper in his very interesting and valuable communication in your issue of Jan. 21, regarding the Grand Forks typhoid epidemic: While I cannot claim to offer information at first hand, some may be presented on what will generally be accepted as fairly good authority. In Vol. XVII., Part II., of the Report of the Tenth Census of the United States, there is given a description of the Red Lake River, in which, on p. 90, the following statements appear: "The distance from source to mouth in a straight line is 105 miles; by river it is over 200 miles." And further on: "The river below Red Lake is very crooked, one stretch of 33 miles by land including about 100 miles by river." The map of Minnesota, in the Continental Atlas, shows the stream between Grand Forks and Crookston to be very crooked, and it therefore seems safe to conclude that the distance "00 miles" given by your correspondent refers to the water distance, while the "26 miles" given by the report of the State Board of Health is the air line distance. It may be here added that a comparison of the report of the epidemic as it first appeared in the Engineering News (May 22, 1895), with the report of the State Board of Health upon it, shows but the single discrepancy just discussed.

In the matter of population, the figures given for Grand Forks by the last three censuses are: 1880, 1,705; 1890, 4,979, and 1900, 7,652; from which, as the epidemic occurred between three and four years after the census of 1890, Dr. Soper's estimate of 6,000 seems entirely fair. The discrepancy as to the duration of the epidemic, whether four or five months, has been due to a slip on my part, and the figures given were those for five months. It is to be regretted that this epidemic did not call forth a Sedgwick or a Soper, but it is to be remembered that it took place but a few months, we might say, after the first scientific investigations of typhoid in this country were published, and when one recalls the large number of interesting and valuable experiences with this disease that have passed unnoticed in communities among our most enlightened medical men, we cannot be too critical of those who struggled in that distant frontier town when at least one in every five were falling victims of the disease; for I think all who have studied such matters agree that even in epidemics the amount of typhoid is underrated rather than overrated whenever a record of cases is made.

There must be among the readers of Engineering News some who have further knowledge of this matter, and we would hope they may see fit to share it with us.

Very respectfully yours,

Gardner S. Williams, M. Am. Soc. C. E.

Hydraulic Laboratory of Cornell University, Ithaca, N. Y., Jan. 25 1904.

Is the Cost of Sewer Trenching a Function of the Depth of the Trench?

Sir: Referring to the criticism made upon my communication to the "News" on Nov. 12, 1903, I wish to say that you misunderstood the meaning of the communication entirely. The title you gave it is a misnomer to start with. It was my intention to have the letter headed "The Price of Sewer Trenching To Vary With the Depth of the Trench."

I never intended, nor does the letter so state that I proposed to deduce formulas either theoretically or empirically that would give the cost of trenching, considering all of the elements which go to make up the cost of such work. I simply wished to show that the work involved in increasing the depth of the trench, or decreasing it, as the case might be, did not vary uniformly and consequently the same percentage would not apply to all depths. Therefore I did not take the trouble to make a strictly theoretical calculus deduction of formula No. (2), but now see that the purpose would have been better understood had I done so. The calculus demonstration was of value only in showing the analogy between the formula derived theoretically and that derived from the actual sewer bids.

It appears to me that a formula such as No. (2) or No. (3) applies as truly to the work of raising earth from a trench as do many formulas which apply to physical laws. Does not the electrician apply many formulas, derived theoretically, to the design of electrical apparatus and find them to be practically correct? Does any one object to the use of higher mathematics in deriving the laws of the flow of underground waters or the interference of one well upon another, such as Prof. Slichter has done? In the latter case there are many factors unknown, and, no doubt, impossible to consider, yet the formulas derived by him (see U. S. Geol. Survey Reports, Vol. 19) are substantially correct, as I am prepared to prove by actual tests.

Perhaps you would be surprised at the assertion more than you have been at my calculus application to trenching, if I should remind you that trees in New Jersey forests grow in diameter and height according to some mathematical law which is nicely shown by curves in the N. J. Geol. Reports on Forests of 1899. I mention these

illustrations to show that it is not an unusual thing to apply mathematical formulas to physical laws.

I do not pretend to claim that, taking a variety of soil conditions, a few sewer bids would show the laws I claim to be true, but I do claim that if you will study the bids on sewers constructed all over the country for a period of years as was done by the writer in deducing formula No. (3), you will find, as I have done, that the average price of specified sizes of sewers shows that the cost varies as the square of the depth of the trench and consequently the formula derived by calculus shows the proper form of the equation. I claim that by use of formula No. (3) a contractor, familiar with the work involved in laying a given size of sewer at a certain depth in a particular locality, can arrive at the probable cost of the work for other sizes of pipe and other depths of trench under similar conditions. Respectfully,

W. G. Kirchoffer, Consulting Engineer.

Baraboo, Wis., Jan. 16, 1904.

A Vest-Pocket Table for Strength of I-Beams and Channels Used as Beams.

Sir: I am sending you herewith a blue-print of a table that I find quite useful (the table is reprinted below.—Ed). It is not always handy for a man to carry a Carnegie handbook around, and this little table will give all the information a man wants for immediate reference. You will note that the carrying capacity of I-beams and channels is made out for 10-ft. span, this being the most convenient span to have in a table, as the carrying capacity of any beam or channel can readily be figured from this, especially with a slide rule.

The carrying capacity of a beam being inversely proportionate to the length of the span, I set the index of the reversed scale opposite the carrying capacity for 10-ft. span, and opposite any length of span on the reversed scale I read on the slide the carrying capacity of the beam for that length of span.

SAFE LOADS ON I-BEAMS AND CHANNELS. Load in Tons, Uniformly Distributed, 10-ft. Span.

Size	I-Beams. 24", 80-lb.	20", 65-lb.	18", 55-lb.	15", 42-lb.	12", 31½-lb.	10", 25-lb.	9", 21-lb.	8", 18-lb.	7", 15-lb.	6", 12¼-lb.	5", 9¾-lb.	4", 7½-lb.	3", 5½-lb.
Safe load, tons	92.8	62.4	47.2	31.4	19.2	13.0	10.1	7.59	5.52	3.88	2.58	1.59	0.88
Add pr lb. inc. in wt.	0.64	0.52	0.48	0.40	0.32	0.26	0.24	0.21	0.18	0.16	0.13	0.11	0.08

Size	Channels. 15", 33-lb.	12", 20½-lb.	10", 15-lb.	9", 13¼-lb.	8", 11¼-lb.	7", 9¾-lb.	6", 8-lb.
Safe load, tons	22.2	11.4	7.14	5.61	4.31	3.34	2.31
Add per lb. increase in weight	0.39	0.32	0.26	0.24	0.21	0.18	0.16

There is no particular feature about this table, except its convenience, being made out in small enough size to be carried in an ordinary card case. If you think it worth publishing for others to copy, I shall be glad to have you use it in this manner. Respectfully yours.

J. A. Holmboe.

Snead Iron Works, Louisville, Ky., Jan. 15, 1904.

Effect of Removing Cement Briquettes from Water for Varying Lengths of Time Before Breaking.

Sir: Relative to the article in Engineering News of Jan. 7 on the effect on the tensile strength of cement of removing briquettes from water for varying lengths of time before breaking, I noticed similar results in the Sanitary District of Chicago cement-testing laboratory in 1896.

Some extra briquettes of Portland cement that were taken from the water and left on a shelf out of water, to be broken as occasion required to illustrate the method to visitors, showed a marked decrease in strength, followed by a gradual recovery of strength similar to the upper curve given by Prof. Van Ornum, though the test was not made systematically as to intervals of time, since such results were not looked for. Stranger yet was the following: It was noticed that when a complete set of 30 briquettes (neat) were taken from the water all at once and broken in order, there was almost always a decrease in strength noticed toward the last of the set, even though only a few minutes, less than an hour, elapsed from start to finish. My recollection is that in very warm weather the last five of a set of 30 neat Louisville or Utica cement briquettes would average at least 10% or 15% lower than the first five and they were probably broken at about the rate of one per minute.

What is the explanation for so sudden a change on drying out? Has the water tensile strength by some sort of capillary attraction in the pores of the cement?

H. P. Boardman.

C., M. & St. P. Ry., Milwaukee, Wis., Jan. 18, 1904.

Tests of Cement Mortar Made from Sand Containing Alkaline Earth.

Sir: In connection with the article by C. E. Sherman, published in Engineering News of Nov. 19, 1903, on the "Effect of Clay and Loam on Cement Mortar," the following tests, made from the materials used in the construction of Golden Gate concrete highway bridge, Yellowstone National Park, may be of interest. The sand used in the tests was submitted to this office by Capt. H. M. Chittenden, Corps of Engineers, U.S.A., from the pit mentioned in the article above referred to, and was used in its natural state. No tests were made to determine the percentage of foreign matter, but the sample was selected as an average and probably contained about 5% of the alkaline earth, etc. The cement used in the tests was Atlas Portland with a fineness of 99.8, 95.6 and 87.6%, passing a No. 50, 74 and 100 sieve, respectively, and having an average tensile strength of 804 lbs. per sq. in. on a seven-day test.

Age.	Strength, per sq. in. 1 cement, 2 sand.	1 cement, 3 sand.
7 days	333 lbs.	292 lbs.
168 "	587 "	496 "
365 "	698 "	533 "
595 "	896 "	683 "
908 "	917 "	702 "

The age given is in days, being one day in air, balance in water, and the strength in pounds per sq. in.; 10.5% of water was used in the mixture.

These tests are of especial interest in the following respects: (1) The original seven-day test showed greater strength than mixtures made from standard sand free from all foreign matter. (2) The latest tests are among the longest on record and indicate a continuous gain in strength with age.

Captain Chittenden states that the structure, although exposed to all the rigors of a cold climate where the temperature falls as low as 50° below zero, and where no part of it stands in water, but is subject to the action of a very dry atmosphere, seems to be in perfect condition with no evidence of weakness or disintegration in any part.

It is difficult to understand, in the fineness test given in the thesis quoted by Mr. Sherman, how the No. 74 sieve arrested more of the cement than the No. 100 sieve. Very respectfully,

J. M. Lewis, City Engineer.

Sioux City, Ia., Dec. 24, 1903.

(In reply to the last sentence of the above letter, it may be explained that the figures in the article in our issue of Nov. 19 represented the results of actual tests. The percentages given referred to the amount of cement remaining on any given sieve after the next coarser sieve had retained its portion. The amount passing a No. 200 sieve should also have been stated. This was about 73 and 75 per cent., respectively, for the Dyckerhoff and Lehigh cements, leaving about 1 per cent. lost in the air, or adhering to the sieve.—Ed.)

The Deterioration of Concrete in Coke Oven Foundations.

Sir: In your issue of Jan. 21 I notice an inquiry about using concrete for lining of bee-hive coke ovens. In building a bank of 108 bee-hive ovens at Superior, Wis., the past summer, Portland concrete in the proportion of 1—3—5 was used for a footing course and the apparent action of the heat upon this may have some bearing upon the subject.

The footing course was built approximately level, and of trapezoidal cross-section, more for convenience of construction than anything else, about 18 ins. on top, 12 ins. on the bottom, and 6 ins. deep. The brickwork rested directly upon this. Sand was used to grade the bottom of the ovens for laying the bottom tile on a slope of about ½-in. per foot from back of oven to the door. This gave a depth of sand above the footing course of about 2 ins. near the door and about 8 ins. at the back of the ovens.

After the ovens had been in operation for about two months the writer examined the footing courses of several ovens, and found in each instance that the concrete had held its shape well, but had apparently lost much of its strength.

When the examination was made the concrete was too hot to be handled with bare hands; it could be broken readily with an ordinary shovel; its color was a rather lighter shade than ordinary concrete and uniform throughout; it was almost impossible to distinguish the sand and cement from the crushed rock; the broken surfaces had a chalky appearance.

Several specimens about the size of 2-in. crushed rock were doused with water until cool enough to be handled; so far as I could see, they showed no signs of cracking and gained somewhat in hardness at the time, but, at the present time, after being in the air for three months, they are crumbly and can be crushed with the thumb and fingers. Yours truly,

Chas. H. Hoyt, C. E.

1402 Tower Ave., Superior, Wis., Jan. 26, 1904.

[This very interesting statement of fact is in accord with the 200 tests made by J. S. Dobie and recorded in the "Digest of Physical Tests and Laboratory Practice." Mr. Dobie found that cement mortar briquettes heated slowly to 1,000° F. lost from 14 to 98% of their tensile strength. Such high heat drives off the chemically combined water of crystallization, and in proportion to the amount of such water lost is the mortar weakened. Obviously the thickness of the concrete and the length of time that it is subjected to high heat are both important factors in the loss of water of crystallization.—Ed.]

The Use of Rakes in Mixing Concrete.

Sir: It is with a great deal of interest that I have read the discussions in your columns concerning the best methods for mixing concrete by hand. As I have not seen anything said as regards the way we mix it here I thought that maybe our method is entirely out of date. I will describe our method as best I can, and would appreciate any suggestions you can offer as to the faults in this method.

We first spread a layer of broken stone or gravel, say, two cubic yards. We smooth this off in a layer 8 ins. or a foot thick. Then we put on this the required amount of sand, and smooth this off level; then on top of this we spread the cement. Now we shovel the gravel from around the edge of the pile up on the center. Then a couple of shovelers begin to turn this mixture over, commencing at one end, another man raking the mixture all the while. Generally one turning is sufficient to thoroughly mix them dry. Then we again turn the mixture over, and, while two men shovel, one rakes and one applies the water. We believe that the cement and sand get better mixed with the gravel or stone by turning dry and then turning wet. And also at the end the stone is more thoroughly covered. Any suggestions concerning this method will be greatly appreciated by

Yours very truly, W. T. Hardison, Jr.

Nashville, Tenn., Jan. 27, 1904.

The Mixing of Concrete.

Sir: The writer has been greatly interested in the letters on concrete mixing which his first communication on the subject called forth.

In his first letter he mentioned the use of bottomless boxes to measure stone and sand. Some of the contributors to the discussion seem to have overlooked the fact that he recommended putting in the cement by weight. It is the only proper way, and a matter easily arranged. One way is to use cement in bags and make each batch of a size to require one bag of cement.

It seems to be immaterial how the aggregates are handled so long as the mixing is thorough. From the standpoint of the contractor, that manner of mixing is best that calls for the least handling by the laborers, and at the same time is thorough. Since the matter is now up, the writer will say that a test has lately been made of the method he mentioned (which is in commoner use than many Eastern engineers seem to believe), and of the method of first mixing the sand and concrete. The two concrete constructions could not be told apart, as the mixing was well done, but the gain in time made a respectable per cent. The writer has handled enough concrete work to entitle him to the belief that he knows something about it. In spite of the opinions of men whom he knows are competent to discuss the subject, he holds that by mixing the concrete dry and sprinkling the water on last, the output per man per day is considerably increased over the mortar and stone method, while the mixing is no less thorough.

The cheapest way to mix concrete by hand is to spread the stone on a tight platform in a layer as many inches in depth as the stone forms part in the mixture. On this spread the sand and on this the cement. Turn it over twice, putting the shovels in at the bottom and allowing the aggregates to fall instead of being thrown. On the third turning add water (preferably from a sprinkler nozzle), and turn it over a fourth time while wet.

It is simply the question of cost we are to consider, not adherence to any particular method, so long as all methods properly followed secure equal efficiency. Some seven or eight years ago the writer in a discussion in Engineering News advocated a wetter concrete than most engineers at that time believed in. He was not prepared then, however, to recommend "mushy" mixtures. With the advent, however, of steel concrete, he has seen concrete poured into forms. Such a wet mixture is necessary to secure the close contact so essential between the steel and the concrete, provided there is no hurry in drawing forms. Where work is to be done quickly and forms used over and over, the mixture should simply be wet with a certain percentage of water and then tamped until it quakes freely. The dry powdery mixture rammed into place is not so good. The tamping is simply to force the stone into the mortar, and anything more will disturb the forms.

The writer takes it for granted that hand mixing on extensive jobs is nearly a thing of the past.

Yours truly, Ernest McCullough,

Engineer Municipal Engineering & Contracting Co.

St. Louis, Mo., Jan. 30, 1904.

The Method of Finishing the Concrete Surfaces of Philadelphia Bridges.

Sir: Responding to your invitation in this week's issue, I submit the method of finishing the surface of concrete that is prescribed on city bridge work in Philadelphia, and that has been practiced during the past season.

It is to remove the forms while the concrete is still "green," and simply wash the surface with water, squirting it on with a nozzle if the work is soft enough, or, if harder, using a scrubbing brush. If the cement be too hard to wash off it must be cut by hard rubbing with a brick or a wooden float and sand, using plenty of water. The removal of the cement exposes the sand and grit or pebbles or stone—whatever the aggregate used may be—leaving a surface that is mostly stone, and is probably as little subject to discoloration and cracks as stone, and as durable as any plastic material can be made.

The age at which the concrete is in suitable condition for washing depends upon the character of the cement, the wetness of the mixture, and the temperature of the air. Generally 24 hours will give proper hardness. In summer the forms have been removed in eight hours with satisfactory results, and in cold weather when the planks were left on to prevent freezing, concrete that had been put in very wet was found at the end of a week to be green enough to wash.

The washing must always be done promptly after removing the forms, because the surface hardens rapidly when exposed to the air.

This method requires that the forms be constructed so as to permit the removal of the lower planks without disturbing the upper, which is easily accomplished by leaving, say, 6 ins. space between the studding and the planking, and backing the planks independently against the studs with wedges, and tacking them there with small cleats.

The finish obtained by washing is rough or smooth, as may be desired, and as the cement be soft or hard, and light or dark, according to the aggregate used. Screenings of crushed dark stone—such as trap-rock—up to ¾-in. in size, with Portland cement in the proportions of 1 of cement to 4 or 6 of screenings, make a facing mortar that will wash up dark and rough. Our specifications require face work to have a stiff granolithic facing mortar laid against the form just ahead of the placing of the concrete, thus preventing the appearance of voids and the necessity of patching.

An important advantage in doing the finishing when the surface is soft is the ease of removing blemishes, such as the fins caused by joints in the forms, and a washed surface prevents the eye from noticing the effect of warped planks in the forms, and is handsome withal. Work that has been finished by "whitewashing" or painting with thin cement shows the imprint of every plank, and often shows also wildly waving brush marks that identify every shift of position of the painter, and in many cases suffers from peeling of the coat.

I send you herewith a specimen of facing, in part washed rough and in part as left by the form.

Henry H. Quimby, M. Am. Soc. C. E.
Assistant Engineer (Bridges), Bureau of Surveys.
Philadelphia, Pa., Jan. 30, 1904.

(The specimen sent by our correspondent shows very clearly the decided improvement of appearance resulting from washing the surface. The dark blue color of the trap-rock screenings is brought out distinctly by washing off the cement, thus affording a relief from the monotonous gray of the cement. Red sandstone screenings used in the same way would doubtless give an excellent effect. By way of contrast, the coping might well be faced with screenings of a color differing from that of the screenings used in facing the body of the wall.—Ed.).

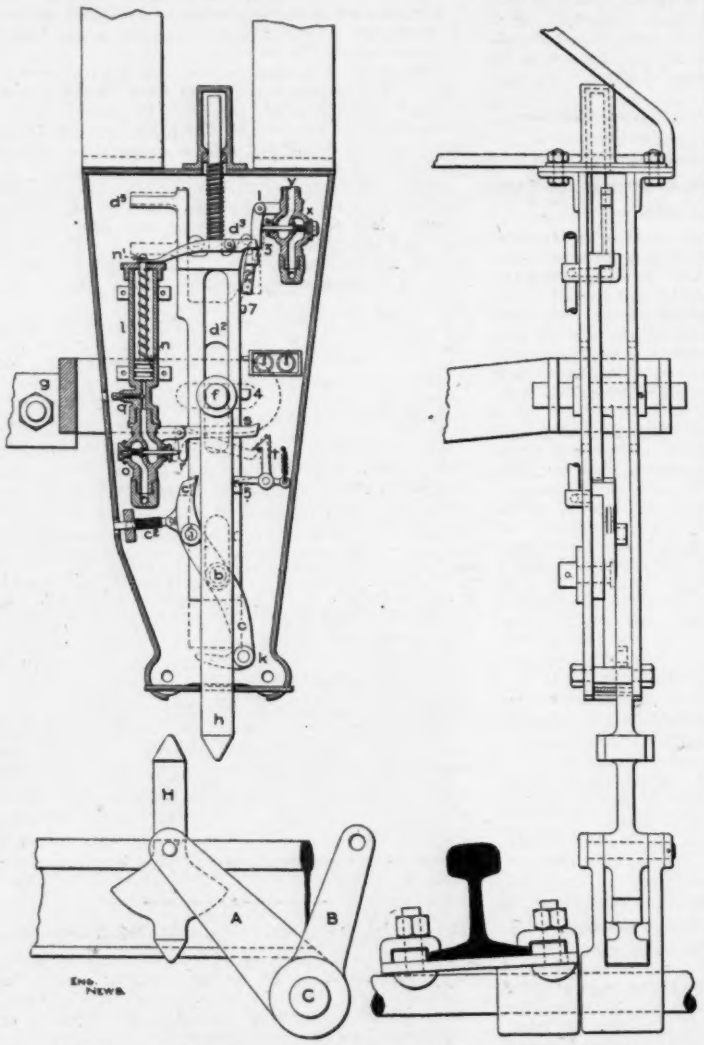
Automatic Stops as Adjuncts to Block Signal Systems.

Sir: While preparing drawings and blue prints of our distance brake apparatus Mr. Schiesser sent me Engineering News of Feb. 19, 1903, containing a very interesting article on the subject of automatic brake setting for railway trains, which I had not seen before, and also an extract from the report of Mr. F. G. Ewald, Consulting Engineer Illinois Railroad & Warehouse Commission.

Studying closely the article referred to I find that our apparatus fills most, if not all, of the requirements you consider essential in an ideal appliance for the purpose. To begin with, our apparatus is the invention of a practical locomotive engineer, Mr. Jac. Graber, Master Mechanic in the Zurich Locomotive Shops of the Swiss Railway, who, as may be assumed, is a man perfectly familiar with the subject.

Even if the practice of running trains and of signaling in European countries may differ in certain respects from that in this country, it does not follow that our machine would not do its work here as well as there, and if requirements should be somewhat different here slight modifications in the application of the apparatus could easily be made.

You lay great stress, rightly, I think, on the fact that railway managers have no means of knowing when an engineer runs past block signals at danger unless his disobedience results in an accident. Our appliance records every such failure on the part of an engineer. Your article further says, that such a device should operate by applying the brakes and preferably also by closing the throttle. Our apparatus performs the first part of this requirement with absolute certainty; for the second part no provision has as yet been made, but I can see no reason why this could not be done if desired and without complicating the apparatus in the least.



Sectional Side Elevation. End Elevation.

DETAILS OF THE SWISS DISTANCE BRAKE OR AUTOMATIC STOP FOR RAILWAY TRAINS.

As to the location of the contacts I do not think there could be any objection to have them placed at the distant signal if so desired. It is, as your article states, wholly inadmissible to have the brakes thrown on every time a train passes a distant signal set at caution, but this need not be done if the engineer attends to his duty. I will refer to this subject further on. I make mention of the location of the automatic stops only for the purpose of demonstrating the ability of our apparatus to accommodate itself to existing conditions.

I am well aware of the difficulties that beset the signal engineer in the operation of long lines of wire or pipe connections, but as this is a matter by itself I think we should leave it to him to decide on location and other details, confining ourselves to the supplying of an apparatus that does the work expected of it wherever placed. I may add, however, that our contacts can be arranged to indicate danger if a wire or pipe connection breaks.

Mr. Ewald, in mentioning a German device of this sort which gave excellent results in trial tests, and which as a result of these demonstrations was to be put to practical use on parts of German and Russian state railways, is evidently referring to our apparatus. It has been adopted by the state railways of Baden, Austria, Switzerland, by the Jura-Simplon system, the Sihl-Valley R. R., and, according to advice from the home office, negotiations with French, Prussian and Russian railways are pending.

The accompanying drawing illustrates the apparatus. The four principal parts coming into action at an automatic setting of the brakes are the revolving contact piece H, carried on the arm of a shaft journaled in boxes fastened to the rails; the pendulum lever h striking against H, and the S-shaped lever c with its upper end in the form of a pawl engaging with a notch in the platen d. The drawings show the relative position of these parts to each other and the manner of their working.

The pendulum lever h is suspended from a piece g which is bolted to an equalizer-bar or an axle-box in order to maintain h at the same distance from the rails. The case containing the apparatus is fastened to the frame of the engine or the truck of a car and follows the vertical motions of that. The case as well as the platen d are provided with vertical slots to permit a vertical movement of about 3 ins. without touching the fulcrum f of the lever h.

On striking the contact H the lever h is deflected, and pressing against one of the bosses k or l of the S-shaped lever c, according to the direction of the impact, will disengage the pawl c, permitting the platen d to drop. To insure a prompt fall d is further forced downward by the coil-spring on its upper end. The platen d carries on a projection on its upper end the roller d3. In falling, this roller opens the exhaust valve y of the air brakes by sliding along the curved valve-lever 2.

This is, in substance, the construction and operation of our apparatus in its earlier form. In simplicity of construction and promptness of action it leaves nothing to desire, but practical operation suggested several improvements. One chance for improvement was that the platen d after having dropped had to be pulled back to its initial position by hand, by means of a chain or wire rope running over pulleys to the cab. Although this arrangement worked well it left too much opportunity for meddling; by simply fastening this chain or rope the platen could be prevented from falling, and in that way the apparatus be made inactive and control impossible.

One of the improvements on the earlier form, therefore, is the introduction of the resetting attachment. This attachment, also very simple in construction, works automatically and leaves no chance for meddling. On the drawings there is seen on the left side of the apparatus the valve o; this valve is connected with the pressure line of the brakes. The platen d in falling opens this valve, the boss 4 pressing against the valve-lever s. Pressure is then admitted to the resetting cylinder l, whose piston-rod n will lift the platen again to its normal position. The time in which this resetting takes place can be modified by the screw q, which regulates the admission of compressed air to the cylinder l.

The piston of the resetting cylinder raises the platen somewhat higher than to its normal position in order to insure a certain engagement of the pawl c, and also for the purpose of releasing the catch t which holds the valve-lever s until the platen has reached its highest position, when the little boss 5 effects the release.

After the valve o has been closed the piston slowly descends under the pressure of the coil-spring in the cylinder, the enclosed air finding an outlet through a small central bore in the valve stem of o, leading to the right-hand chamber of the valve. This bore is closed by the short arm r of the lever s while the valve is open, but after the release of s no appreciable resistance is offered to the escape of the air. The cycle of these operations takes place in from two seconds to two minutes, according to the regulation of the screw q. The apparatus in its present form, while the extreme simplicity of the former arrangement in regard to its working is maintained, makes it independent from any interference on the part of the engineer; in fact, it makes it impossible for him to interfere, while at the same time it records any failure on his part to attend to his duty.

I made mention of the undesirability of having the brakes thrown on at every signal set at caution; as our apparatus would do that, I have designed a simple attachment which will overcome this difficulty. From the pressure reservoir I lead a pipe to the cab. At its upper end this pipe carries a valve, the handle of which is connected with the brake handle and can only be operated in conjunction with the brake. Another pipe leads from

the valve to the resetting cylinder of the automatic brake apparatus.

The operation of this device would then be as follows: The engineer approaching a green signal set against him would naturally shut off steam and apply his brake in order to reduce speed; but by applying his brake he would also admit compressed air under the piston of the resetting cylinder, which piston, rising, would prevent the platen from descending and consequently prevent the setting of the brakes. Should the engineer fail to apply the brakes then our apparatus would do it for him and make a record of his failure.

I may be permitted to repeat my statement that whatever the conditions in regard to signaling on different roads may be our apparatus will readily adapt itself to different requirements. Very respectfully yours,

G. L. Schiesser & Co.,
Geo. G. Wacker, Consulting Engineer.

New York, N. Y., Dec. 22, 1903.

Concerning Requirements for Admission to Engineering Societies.

Sir: The letter of Mr. Colles in Engineering News of Jan. 28 seems to the writer timely. In 1890 or 1891 the writer wrote a letter to your esteemed paper outlining quite a plan for examining engineers. The idea was to have different grades of membership in engineering societies. All admittance should be by examination to the lowest grade and promotion according to experience. No balloting should be done, and no social qualities should be essential, but a strict adherence to a code of ethics to be insisted upon.

The editorial comment on the letter was kindly, but gave the writer a "squelched" feeling, for it was declared to be an idea held particularly by younger members in the profession.

Since that time the Institution of Civil Engineers has adopted such a system of examinations to scare away unworthy applicants. The Canadian Society has fallen into line, and now the "dream of the younger members" may become real.

The writer was told that a man was reasonably certain of election to membership in our national engineering societies if he followed two rules: First, join before you have been long enough practicing to have made enemies of professional brethren. Second, be careful to select as sponsors men who have made no enemies, that is, be careful not to have any men of high standing endorse you, for their enemies will cast blackballs.

If this is true, then members should be elected by the Board of Directors (as in the Western Society of Engineers), or be admitted on examination without balloting (as in the Canadian Society of Civil Engineers).

Nearly every engineer has friends who have been denied admittance to the leading societies, yet whose ability and professional standing is not questioned. It is a pity that this can be. No one can climb without creating jealousy, and in the struggle for life—not mentioning success—a man is bound to make some enemies. If he is forceful he will at times gives offense. Engineers should be too large-minded, however, to deny the ambitious successful brother proper recognition and standing.

Yours truly, "A Western Engineer."

St. Louis, Mo., Jan. 30, 1904.

Cost of Maintenance of the Union Engineering Building.

Sir: I have followed the discussions on the matter of the proposed Union Engineering Building, and especially the very dispassionate statement of the Board of Direction accompanying the letter-ballot through which the members of the American Society of Civil Engineers are to express their will as to whether their society shall accept or reject the proposition.

In all the discussions or statements I have not noted any figures of the probable cost of maintenance of a building such as that proposed. As that is a matter to which every member would give consideration and weight if it concerned his individual welfare, it is none the less of vital importance to us as a Society..

In order to obtain definite information of the cost of such maintenance, I have been furnished with a detailed statement by one of the best-known agents and managers of such buildings in New York City, the sum total of which foots up to $30,000 per annum, and this exclusive of taxes.

Of this $30,000, on the basis of the plan of assessment proposed, the American Society of Civil Engineers would be obligated to pay from $10,000 to $15,000 annually.

The cost of maintenance of our present building for the past year has been $3,619.03; this has more than met all our requirements, except for one day, when we were obliged to rent a hall for the annual meeting.

We can well afford to pay the rent of a hall once a year and still have a goodly balance to use for the advancement of the welfare of our Society and the good of the profession.

I would not have the honorable profession of Civil Engineer suffer from sordid motives nor from narrow-mindedness, but I am convinced there is much greater danger (to our younger members, at least) from atrophy superinduced by the acceptance of the magnificent gift offered by Mr. Carnegie. Very truly yours, F. S. Odell.

Port Chester, N. Y., Jan. 29, 1904.

The Union Engineering Building—Questions of Finance.

Sir: In the summary of arguments for and against the American Society of Civil Engineers uniting with other societies in the joint occupancy of a Union Engineering Building, as set forth by the Board of Direction of the Am. Soc. C. E., the allegations on one important point are too indefinite to enable the reader to form a clear opinion as to whether the proposed union is financially desirable.

On the one hand it is alleged that "the advantages to be gained by the common use of auditoriums, reading rooms, etc., could probably be obtained at less cost of maintenance and operation than where different establishments are maintained," while on the other hand it is stated that "it is the opinion of experts in the management of buildings that the expense to the Society by becoming a participant in the management of the proposed building would be very greatly in excess of its present expenditure for operation of its own building."

The first statement is a mere general supposition. The second statement is based upon the following facts:

The cost of maintenance of the House of the American Society of Civil Engineers for the last three years is thus given in the annual reports of the Treasurer:

	1901.	1902.	1903.
Caretaking	$1,417.53	$1,582.23	$1,794.42
Maintenance	156.96	334.71	542.47
Heat, light and water	873.90	1,068.79	1,242.14
Betterments	214.50	29.48	40.00
Total annual expense	$2,662.89	$3,285.21	$3,619.03

Average annual cost of maintenance, $3,189.90.

An estimate in detail of the annual cost of operating a ten-story building of 125 ft. frontage, containing three auditoriums, library space, offices and committee rooms for four separate organizations has been prepared by one of the most experienced firms in the management and control of large buildings in New York City, as follows:

Janitor, scrubwomen, watchmen and porters:		
Weekly pay roll, $159		$8,268
Elevator and hall men, $61		3,172
Janitor's supplies		1,000
Engine-room pay roll, $107	$5,564	
Coal	6,000	
Steam and electric plant:		
Supplies and repairs	3,000	
Water tax	1,500	
Heat, light and water		
Miscellaneous repairs		1,500
Total annual cost of operation and maintenance		$30,004

This agrees very closely with estimates made up from statements by a number of owners of large properties who have been questioned on the matter. The amount named is probably less than the actual cost in most of the large buildings now in operation.

In the proposed Union Engineering Building, the cost of operation is to be divided among the four occupants in proportion to the space occupied by them. The American Society of Civil Engineers having a larger membership than any of the other Constituent Societies, will necessarily be assessed more than one-fourth of the expense of maintenance. The least proportion of the expense which it will be called on to pay will be three-eighths of the whole, or $11,250 per annum. That is about $8,000 per annum more than it now has to pay.

The amount which it will be able to expend for publications and towards the extinguishment of its indebtedness will be diminished by at least $8,000 per annum.

This is not all. The annual expenditures for interest and insurance during the last three years have been: In 1901, $3,190; in 1902, $2,700; in 1903, $2,400, decreasing yearly as the mortgage is being paid off. In the Union building it would have to pay one-fourth of the interest on the bonded debt of $520,000, and one-fourth of the insurance, amounting to about $5,500 per annum. It is true that the proceeds of the sale of the present house would in all probability be sufficient to pay off the present indebtedness and also to invest the balance in the $130,000 worth of bonds on the new property, which the Society is authorized to hold, but the fact would remain that the Society would be responsible for the interest on the entire $520,000 issue of those bonds in case of default in payment by any of the societies associated in the ownership of the building.

The nominal assets of the Society will be increased about $250,000, but that additional asset and also about $130,000 of its present available assets will be tied up in an inalienable, undivisible piece of real estate controlled entirely by a corporation in which the Society will have only one voice out of four in its management.

New York, Jan. 30, 1904. "Member."

The Proposed Union Engineering Building.

Sir: In reading the very interesting arguments for and against co-operation in the proposed Union Engineering Building in the pamphlet issued by the Board of Direction of the American Society of Civil Engineers, I find one set of objections stated on page 6, which, in my opinion and experience, appears to be based on false assumptions. The assertion is made that:

> The experience had in the management of high buildings in New York and elsewhere is to the effect that the cost of operation, per square foot of floor space occupied, is very much greater in a ten-story building with elevators than in a four or six-story building without elevator service.

This is a most self-evident statement in itself, but its application to such a building as the proposed Union Engineering Building is quite inappropriate.

The cost of elevator service is, of course, a necessary concomitant of increase of height above 4 or 5 stories, but its extent and character is dependent on the nature of the usage of the upper floors.

In an office building where all floors are in equal use, it may be regarded as a burden on the operating cost of all floors above the first, since even the tenants of a second story demand its use. The maintenance of a schedule service, which forms the major expense of elevator operation, is not to be considered a probable requirement in a Society building, in which the greater use is in the two lower floors. The conditions would not even approximate those of an apartment hotel, whose tenants at upper floors necessarily require a regular use of elevators.

A transient hotel system is somewhat nearer, the major use of which is in its lowest floors, with a comparatively limited travel of each tenant to an upper floor. But even this goes beyond the probable requirements in the Engineering Building.

The wasteful character of schedule service, in most of which steam is used in excess of what is required for house heating, will be absent, and the elevator work if properly planned may be considered to come within the demand for steam in heating the house, and, therefore, during a large portion of the year, to be a by-product. The same will be true to a certain extent of the lighting load, the periods of major light demand coinciding with that of major heating. A carefully planned system of services should bring the winter work of the house to a point of great economy. The greater use of the building will be during this period of the year, and by a judicious combination with outside services of power supply, the labor bill for the remaining two-thirds of the year may be kept within the most moderate limits.

Nor can the allegation be sustained which is made in a succeeding argument, that:

> in the opinion of experts in the management of buildings, the expense to the American Society of Civil Engineers by becoming a participant in the management of the proposed building, would be very greatly in excess of its present expenditure for operation of its own building.

On the contrary, the proportion of dead items of maintenance which the Society will bear should be less than it now carries alone, since the proportion of contents of the new building which will compare with the present Society house will have less burden of dead charges. Its share is less of heat losses, of standing costs of lighting for corridors, toilets and other dead spaces, and of water for sanitary work, while its share of wear and tear of public rooms, spaces, etc., is reduced.

I do not find among the arguments in favor of co-operation any reference to the improvement which it may be hoped will be found in the new building upon the present auditorium of the Society, which is, acoustically, a lamentable failure, and in design and proportion inappropriate and inadequate.

Finally, I fear that if the Society should decline to join in the Union building, it will find itself greatly the loser. Its present advantage of the possession of a fine building will be discounted by the erection of the Union building in some other form, which project, it is quite probable, will proceed even without our co-operation, and then the whole strength and advantages of co-operation will bear against its progress by the competition of the other united Societies.

I for one, therefore, hope that every member will on consideration cast his vote in favor of the union of our Society in the projected home.

Reginald Pelham Bolton, M. Am. Soc. C. E.

35 Nassau St., New York City, Jan. 31, 1904.

(In comment on the above three letters it may be said in the first place that until more definite plans are made as to the size and arrangement of the proposed building, no very accurate estimate of its running expenses will be possible.

In the second place, it would be contrary to all past experience if the cost of lighting, heating and keeping clean a given area of floor space were not considerably less in one large building than it would be for the same area in four separate buildings.

It is true that the cost of elevator service will be an added expense; but suppose one compares the average number of daily visitors to the present house of the Civil Engineers or the present house of the Mechanical Engineers with the number of those who come and go to offices covering a similar area in a downtown office building. Such

a comparison will make clear the reason why the expense for elevator service in the proposed Engineering Building should be trifling compared with similar service in an office building.

A considerable part of the space in the proposed building will be taken up by a large auditorium, and probably two smaller auditoriums, and there need be no expense for heating, lighting and cleaning these except when they are used. For reasons which have been made obvious to everyone of late, the auditoriums in the building would be located on or near the ground floor, where elevator service for them would be unnecessary.

Of course it would be possible to conduct such a building in an extravagant manner, so as to make its maintenance a burden on the societies using it. No reason is apparent, however, why the representatives of four engineering societies should not be as successful in securing economical administration as are the representatives of a single engineering society.—Ed.)

Notes and Queries.

Through a typographical error in the note published in our issue of Jan. 21 on the temperature of air and sewage at the sewage purification plant at Plainfield, N. J., the temperature of the air was given as about 10° F., whereas it should have been — 10° F.

Prof. Leslie A. Waterbury, of Urbana, Ill., calls our attention to an error and to a possible cause of misunderstanding in our report of the annual convention of the Illinois Society of Engineers and Surveyors, in our issue of Jan. 28. In our abstract of Professor Waterbury's paper on "Present Practice in Road Construction in Northern Illinois," the cost of a 20-ft. roadway should have been given as $5 per rod instead of "per lin. ft." The third column in the table condensed from Professor Waterbury's "Economy of Various Methods of Leveling," should have been headed "Cost divided by accuracy."

ANNUAL MEETING OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Canadian Society of Civil Engineers held its annual meeting at Montreal, P. Q., on the three days of Jan. 26 to 28, 1904. Founded in 1887, it enters upon its eighteenth year in vigorous and promising condition, financial as well as otherwise. It has a well-equipped house, located at 877 Dorchester St., Montreal, which is now wholly clear of debt; the membership list is increasing at a steady rate, and the society's affairs are conducted so as to yield a safe yearly surplus.

The past year has been an important one for this society. Several sections* devoted to individual branches of engineering were established, in order to secure more detailed and thorough discussion of specialized engineering questions. Sentiment has also crystallized in favor of the formation of local branches or chapters, in the principal cities of the Dominion. Both these movements are in the direction of greater breadth and influence of the society's work.

It is to be remembered in connection with the Canadian Society of Civil Engineers that the conditions and standing of engineering in Canada are somewhat different from those in the United States. Surveying is a "close profession" in most, if not all, provinces of the Dominion, its practice being restricted to members of specific incorporated societies which in other respects are similar to the various State engineering associations in this country. In engineering work other than surveying it is held equally desirable to restrict practice. The province of Manitoba in 1896 passed an act which recognized the Canadian Society of Civil Engineers as an official association of engineers and restricted practice to members of the society (and certain specified exceptions). A similar act, though more stringent in its restrictive provisions, was passed by the Quebec Legislature three years later. The society desires to extend such restriction to the entire Dominion, and an attempt has been made to have the Dominion Parliament effect this by a single enactment. However, as was pointed out by Senator Casgrain at the society's banquet, such a proceeding is impossible because the British North America Act specifically leaves to each province the right to regulate the professions within its border.

*The sections are as follows: Mechanical Section, Electrical Section, Mining Section, and General Section.

The extension of the society by growth must therefore be relied upon to give it such a position in the different provinces as will aid in securing the passage of acts like those of Quebec and Manitoba. Even aside from the matter of "close corporation" laws, of course, the society has every reason to desire the fullest possible extension into all the provinces of the Dominion; and, according to a policy already inaugurated, this will be developed by the formation of local chapters. At the first session of the meeting, on Tuesday morning, Jan. 26, it was voted to recommend to the council the desirability of appropriating a certain sum to any local branch for the purpose of acquiring a library. It is believed that a good technical library will be the best stimulus to the healthy growth of a local branch.

The report of the council of the society, also submitted at the first session of the meeting, showed the following statistical facts: Total membership 1,147, of which 378 are full members and 362 are students. The year's receipts were $7,897, against expenditures of $6,682, which latter amount includes the final payment of $1,248 on the building mortgage. The total assets of the society are computed to be $27,256, with no offsetting liabilities, but less than $2,500 of this amount is in cash.

The election of officers for the year 1904, by letter ballot, resulted in the election of Lt.-Col. W. P. Anderson, Chief Engineer of the Department of Marine & Fisheries, Ottawa, Ont., as President. Prof. C. H. McLeod, of McGill University, Montreal, was re-elected Secretary, and Mr. H. Irwin, of Montreal, Treasurer. The meeting also voted, on motion of Mr. W. T. Skaife (Montreal), to recommend to the council that the First Vice-President of each year be selected as the nominee for President for the succeeding year. Besides its other advantages, this plan will also secure proper rotation of the presidency among the various sections, since the vice-presidents are chosen to represent the several sections.

An unusual matter of business came before the society by motion of Mr. J. L. N. Coste (Ottawa). A paper read before the society a few months ago contained remarks which were interpreted as referring in derogatory manner to certain other members of the society. Mr. Coste asked that a committee be appointed to investigate the matter in order to determine how far these remarks were improper, and, if found suitable, to publicly censure the author of the paper. The motion was subsequently modified by eliminating the part relating to censure, and adding that the findings of the committee be referred to the council and sent out to the membership; in this form the motion was carried.

The annual meetings of the Canadian Society of Civil Engineers, like those of the corresponding American society, are devoted mainly to business matters and to social intercourse, technical papers and discussions being handled in the regular meetings held through the year. Nevertheless several interesting technical matters came before the meeting, as appears from the following summary:

FREIGHT RATES.—The address of the retiring President, Mr. K. W. Blackwell (Montreal), was a review of some freight rates on American railways and on Atlantic shipping rates. It clearly showed the great difference between rail and water rates, both average and minimum, and a forecast was made of the future changes in rates. Mr. Blackwell did not hold out hopes of decreased water rates, since both the transportation and the terminal service in bulk-freight has been developed practically to a maximum (grain and iron-ore are the chief items in this traffic). Railway rates are still slightly on the downward trend, through the reduction of ruling grades, more general use of maximum locomotives, and hence heavier train-loads; but the decrease of rates is small at present, and there is little margin left for further decrease. The electric (alternating current) locomotive was held to offer a promise for substantial reduction in rates beyond what is possible with the steam locomotive. We hope to present this paper in full in the near future.

ELECTROTHERMIC METALLURGY.—An illustrated lecture on "Recent Developments in Electrometallurgy, with especial reference to Iron," was delivered by Dr. Stansfield, of McGill University, Montreal, at the session of Tuesday afternoon, Jan. 26. The lecturer showed drawings of various types of electric furnaces which have been tried in iron or steel making, among them the Stassano, Keller, Heroult, Kjellin, Harmet, and Ruthenburg furnaces. All the workers in this field have to face the fact that the ordinary metallurgical processes (iron) are of very high efficiency, so that there is little margin for economy. On the other hand, the electric heating has the advantage that it may be used to develop the heat just where and when wanted, and further that very high temperatures may be reached. Usually electric energy costs far too much to make its use commercially possible for metallurgical work. An exception is the manufacture of certain alloys, which are found at very high temperatures and must be kept free from impurities; in this work the electrothermic method finds commercial application. But in regions where fuel is very costly, and where water-power electricity can be had at exceptionally low cost, the electric process may be the cheaper. Under very favorable conditions, electricity from water-power may be had for about $10 to $12 per horse-power-year, or 0.13 cent per horse-power-hour; with this cost, coke fuel would have to cost more than $10 per ton in order to make the electric process the cheaper. The power required for the blast is so small as to be negligible, amounting to only about one-thirtieth of the power required for the electric smelting. Nearly half the fuel used in the ordinary blast furnace is required for the chemical reduction, irrespective of heat production. At the conclusion of the lecture, Dr. Stansfield showed some small electric furnaces in operation. An arc furnace, in which the arc was forced downward upon the surface of the charge by magnets, was exhibited by projecting a top view of the furnace in action upon the screen by means of a mirror.

NEW LOCOMOTIVE AND CAR SHOPS.—At the session of Tuesday evening, Jan. 26, two papers were read which described new shops located at Montreal. Mr. M. J. Butler described the shops of the Locomotive & Machine Co., at Longue Pointe, Montreal, and Mr. Henry Goldmark described the new car and locomotive shops of the Canadian Pacific Ry. at Montreal. These papers were in a sense explanatory lectures, as on the following day the society visited both shops and examined their layout and construction in detail. Both shops are very interesting in many ways, and we hope to present descriptions and illustrations of them in a short time.

The Locomotive & Machine Co.'s shops are arranged in a series of connecting buildings; the roofs are of flat pitch, it being thought that this will result in less trouble from snow than with steep roofs where the wind has less tendency to blow the snow off the roof. Traveling overhead cranes and an abundant supply of radial jib cranes serve the shops. Heating and ventilation is provided by hot-blast installations served with steam from the power-house. The driving is by induction motors arranged for group driving in the case of the smaller machines. A noteworthy feature of this plant is that it was all built on the grounds, the steelwork being fabricated in a temporary structure equipped as a structural shop. The entire erection was accomplished in remarkably short time.

The new Canadian Pacific shops, which will be called the Angus shops, form a vast plant. The buildings here are all separate, and are arranged with proper reference to the course of work through the shops. Freight and passenger cars and locomotives will be built and repaired here. The buildings are founded in a peculiar manner, on account of the soft clay soil overlying the rock for a depth from zero to 20 ft. Trenches were excavated in winter along the lines of the walls, and filled with roughly-coursed dry rubble, constituting virtually a dry-masonry wall from rock to ground level. The stone laying was done by laborers, and cost $2 to $2½ per cu. yd. The buildings are all brick-wall structures. The roofs are of three classes: 1, wooden Howe truss roofs; 2, wooden beam roofs on wooden columns; 3, steel

truss roofs. The purlins in all cases are of wood, up to 8 × 16 ins., and the roofs are of 3-in. plank.

No gutters or down-spouts are fitted, as they were believed to be more troublesome than useful. A full equipment of automatic sprinklers is provided, and very low insurance rates were secured. Heating is by hot blast, using exhaust steam the greater part of the year. Electric motors are used for driving, in a mixed system, part direct and part alternating current. The locomotive shop is arranged on the longitudinal plan, with enough space between the pits to allow engines carried by the overhead crane to pass those standing over the pits.

As already noted, the second day of the meeting was spent in an excursion to the two shops just referred to. On the way the transformer substation of the Showingan transmission was also visited. This system has since its construction been tied into a common system with the other electric transmission lines reaching Montreal, and a very complete system of transformation has resulted. The incoming Shawinigan line is three-phase, about 4,500 volts, and this is transformed by synchronous motor-generator sets to two-phase 2,500-volt current at the station in question. There is the necessary accompanying equipment of step-down transformers, lighting arresters, raising transformers, etc.

The social events of the meeting were: An informal luncheon at the society's house on Tuesday, Dec. 26; a banquet at the Windsor Hotel on Wednesday evening, and an afternoon tea in the society's house on Thursday. The dinner was the climax of the meeting. Toasts were drunk (and duly honored) to the King, to the retiring officers, to the visiting members, to sister societies, to the society itself, to the dinner committee, and ultimately to the press. Among the speakers were: Retiring President K. W. Blackwell, Prof. H. T. Bovey of McGill University, Mr. R. A. Ross, Senator J. P. B. Casgrain, Mr. B. T. A. Bell, Mr. G. A. Mountain, Major S. Howard, the President-elect; Lt.-Col. W. P. Anderson, Mr. W. M. Walbank, Mr. R. B. Rogers, Mr. H. O'Sullivan, Mr. E. Marceau, Mr. M. J. Butler, and others. The versatility of Canadian engineers was excellently illustrated during the banquet by Mr. O'Sullivan, who sang an Irish and a French song, and both equally well.

THE FERRELL PROCESS FOR PRESERVING AND FIRE-PROOFING WOOD AND TEXTILE FABRICS.

We give herewith some particulars of a fire retardent process which after some ten years of experimental work, is being put forward by Mr, J. L. Ferrell, of the Ferrell Flameless Wood Co., of Philadelphia, Pa.

The chemical employed is sulphate of alumina, a strong solution of which is forced into the wood under a pressure of 450 to 600 lbs. per sq. in., according to the character of the wood. Hydraulic accumulators are used to give a steady pressure, free from shock. There is no preliminary steaming of the wood, and no vacuum process to extract the sap, the impregnation under pressure being the sole process, and requiring from 15 minutes to two hours. The chemical is said to cost only about 0.75 cts. per lb. When flame or intense heat is applied to wood thus treated, it will char at the point of contact, but it will not burn or burst into flame, the destructive effect of the heat being purely local. The same chemical is the basis of a paint which can be applied to the surface of untreated wood. When this is attacked by flame it forms a hard, rough crust which appears to effectually protect the wood. For treating ties and bridge timbers, which are to be made proof against decay as well as fire, a proportion of ferric sulphate is added to the alumina solution, the former material acting as a coagulant. A number of ties have been treated experimentally.

A peculiarity of the process is that ties and timbers are treated individually in cylinders just large enough to contain one tie or timber of commercial size. The cylinders are closed by hydraulically operated valves, instead of by swinging doors, thus saving much time in operation. A treating plant could consist of batteries of cylinders of the desired sizes, with ample mechanical means for handling the ties or timbers. One advantage claimed for this individual method of treatment is that all the parts are comparatively small, so that plants can be readily removed to sites convenient to the timber supply.

The Elliott Cresson medal has been awarded by the Franklin Institute to Mr. Ferrell for his process, and he has recently read papers in Chicago before the Western Society of Engineers and the Chicago Architectural Club.

CONCRETE MIXTURES IN THE BIG MUDDY BRIDGE: ILLINOIS CENTRAL R. R.

The proportions of the concrete mixtures used in different parts of the Illinois Central R. R. Company's concrete arch bridge were accidentally omitted from the drawings accompanying the article in our issue of Nov. 12, 1903. As some inquiries have been received in regard to the composition of the concrete, we give the following particulars, as furnished by Mr. H. W. Parkhurst, M. Am. Soc. C. E., Engineer of Bridges and Buildings:

In general, foundation concrete built within cofferdams or sheeting was proportioned with 1 part of cement, 3 parts of sand and 6 parts of crushed stone. Where, however, heavy masses of concrete were required, having a great thickness and carrying nothing but compressive load, the centers of these masses were made of concrete with 1 part of cement, 4 parts sand and 8 parts crushed stone.

The bodies of piers, bench walls, and walls built within molds were proportioned with 1 part of cement, 2½ parts sand and 6 parts crushed stone. For all arch crowns and rings, and in general where any tensile strain was to be provided for, the proportions were 1 of cement, 2 of sand and 5 of crushed stone. Where special additional strains were to be provided for: 1 of cement, 2 of sand and 4 of crushed stone were the proportions. All exposed work was made with a mortar finish, this being placed next to the face of the molds, as the work progressed.

QUESTIONS ASKED IN THE NEW YORK CIVIL SERVICE EXAMINATIONS OF JANUARY 12, 1904.

The most largely attended civil service examination for engineering employees ever held in this country, probably, was that conducted by the New York Civil Service Commission on Jan. 12 and 16 to prepare an "eligible list" for appointments on the Barge Canal work. Through the co-operation of the United States Civil Service Commission, examinations were held on the same date in a large number of cities in other parts of the United States. As reported in our issue of Jan. 21, nearly 2,500 applications for these examinations were filed with the Commission. The number of appointments to be made is estimated by the State Engineer to be 15 Resident Engineers at $2,400 a year; 45 Assistant Engineers at $5 to $6 a day; 45 levelers at $4.50 to $5 a day; 25 draftsmen at $4 to $5 a day; 45 rodmen at $3.50 to $4 a day, and 90 chainmen at $2.50 to $3.00 per day.

Of the applicants for positions above the grade of rodmen, considerably over half were residents of New York. The law provides that if the civil service eligible list contains three or more residents of New York, they shall be preferred over any non-resident in making appointments. Examinations of chainmen and rodmen were held in New York State only.

We print in full the questions asked in each examination with the principal requirements below:

RESIDENT ENGINEER.

(Applicants must have had at least five years' practical experience in civil engineering work, three years of which must have been in responsible charge. In rating applicants, experience, education and personal qualifications rated upon the applicant's statements and reports from his previous employers will count 5 and two theses required from the candidates will count 5.)

THESIS No. 1.—This thesis should be an engineering description of the piece of work carried out under your charge or control which you consider most important or most interesting from an engineering standpoint. It should not exceed 4,000 words in length and should be submitted in typewriting (double space) on paper of legal size either 8 × 13 or 8½ × 14 ins. written on one side of the paper. Articles previously written or published may be submitted for this thesis provided they conform to the specifications stated above. It is essential that the exact relation of the applicant to the work described should be shown by the thesis and that it should be a description of the work, or portion of the work under his charge and not of work on which he was a mere employee. This thesis should be signed with the candidate's name as it appears in his application.

THESIS No. 2.—This is to be in the same form as Thesis No. 1 and should not exceed 4,000 words in length. It should be signed in the handwriting of the applicant with an assumed name or identifying designation, and the real name and address of the applicant should be placed in a sealed envelope bearing on the outside the same name or designation, also in the handwriting of the applicant. The thesis must disclose either in its body or in foot-notes all books or other references used in its compilation with the reference to the page or portion of the matter used, and must be accompanied by an affidavit setting forth that said thesis was composed by the applicant in person and that all books or other sources of information utilized by him in the preparation of such thesis are properly indicated by reference either in the body or foot-notes of said thesis, and that no other books or works of reference were used as the basis for any portion of said thesis. This thesis must be a discussion of one of the following five topics:

1. Topographic surveying and mapping—methods, etc.—as applied to the proposed barge canal.
2. Theoretical determination of the run-off from watersheds and flow of streams and rivers.
3. Methods of determination of run-off and flow of streams and rivers from actual measurements.
4. Design and construction of locks, dams, or other structures necessary in canal or river canalization projects with especial reference to the proposed barge canal. (Either a general discussion of some line of structures or a specific design.)
5. Description of various methods of wet and dry excavation of earth and rock as required on the proposed barge canal with discussion of the different classes of machinery adapted to different classes of excavation, the cost of such machinery and of excavation, and a description of the different methods of measuring and paying for wet and dry excavation of earth and rock.

The two theses above mentioned must be completed and forwarded to the Chief Examiner of the State Civil Service Commission at Albany, N. Y., before Feb. 4, 1904.

ASSISTANT CIVIL ENGINEER AND LEVELER.

(Candidates for Assistant Civil Engineer must have had at least three years' practical experience in civil engineering, one year of which must have been in responsible charge of work. A three years', or more, course of study in a satisfactory school of civil enginering will be considered equivalent to one year of practice. Rating as follows: Written examination, 10; experience and personal qualifications, 7; education, 3.)

(Candidates for Leveler must have had at least two years' practical experience in civil engineering, and three years in an engineering school may count as one year of experience. Rating as follows: Written examination, 5; experience and personal qualifications, 3; education, 2.)

(Sheet 1, same for Assistant Engineer and Leveler; second sheets different.)

Directions.—Time allowed for the whole written examination, 8 hrs. In the case of problems, all the work of solution must be given. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet.

1. Give in detail the best method of mixing Portland concrete "by hand." Give the reasons why Portland cement is generally preferred to natural cements.
2. Describe fully and in detail the proper method of preparing the subgrade for a macadam highway (a) across a level, sandy farm, (b) in a hilly and rocky country, (c) across a swampy country with a subsoil of clay.
3. What are the most important requirements for which provision must be made in the construction of a macadam highway?
4. In the construction of a macadam highway, how would you prevent (a) "ravelling," (b) sinking of the stone into the subgrade, (c) rapid powdering or disintegration of the stone, (d) a muddy or dusty road?
5. Explain in detail how you would take a series of accurate levels for determining the flow of water in a level country. How do you determine accurately the depth of the water over the crest of a weir?
6. A beam 12-ft. long is held in a horizontal position, one end resting against a vertical wall; the other end, which is to sustain a weight of 600 lbs., is supported by two guy ropes fastened at the top of the wall 16 ft. above the beam, one 5 ft. to the right and the other 6 ft. to the left of the beam, which is perpendicular to the wall. Find the stress in the two guy ropes and the thrust of the beam against the wall.
7. What is the theoretical horse-power that may be supplied by a waterfall 90 ft. high and 84 ft. wide when it delivers 16 cu. ft. of water per second for every foot of its width?
8. The waste gate in a sluiceway is 4.75 ft. wide; the water on one side is 9 ft. 6 ins. deep and on the other 3 ft. 3 ins. deep. Find the amount and the position of the resultant water pressure on the gate. Find the theoretical velocity with which the water will begin to flow when the gate is raised 6 ins.
9. What fall must be given a waterway 2,640 ft. long, 123 ft. wide at the top, 75 ft. wide at the bottom, 12 ft., deep, that it may convey 1,800 cu. ft. of water per second? (Take $c = 88$.)
10. A masonry reservoir wall weighs 120 lbs. per cu. ft. and is 28 ft. high. It is 3.5 ft. thick at the top and has a front batter of 1 in 6. What should be the least back batter and thickness at the bottom in order that it may safely retain water level with the top?
11. The following is a portion of a set of field notes for a stadia survey. One full space on the rod corresponded to a distance of 100 ft. from the center of the instrument. The elevation of the instrument station was 131.57 ft. You are required to calculate the corrected distance, the difference in elevation and the elevation as called for by the columns below.

Stadia.	Horizontal angle.	Vertical angle.	Corrected distance.	Diff. in elevation.	Elevation.
0.04	84° 37′	+8° 1′	....	....	....
0.89	132° 55′	−1° 33′	....	....	....
1.10	91° 10′	+3° 12′	....	....	....
0.90	39° 18′	+4° 52′	....	....	....
1.65	42° 30′	+3° 22′	....	....	....
0.13	249° 6′	+3° 32′	....	....	....
0.40	308° 24′	+9° 35′	....	....	....
1.30	336° 4′	+4° 57′	....	....	....
1.35	288° 54′	+3° 23′	....	....	....
0.52	228° 45′	+3° 53′	....	....	....

12. Plot to suitable scale the elevations you have determined in the above question and by them draw contour lines for each even foot of elevation. Do not erase the

points plotted after drawing the contours. (If you are unable to calculate the elevations called for above, assume a reasonable set of elevations and plot as directed.)

(Sheet 2, for Assistant Civil Engineers only.)

Directions.—In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full.

1. A stream of surface width 50 ft. and depth 4 ft. has side slopes 1¾ to 1. The sides and bottom are of coarse gravel and pebbles with some large stone; the bed has a general fall of 0.5%. Find the height of the submerged weir that will double the depth, taking into account the velocity of approach.

2. Find the pressure of the stream against the weir in the above question and design the weir, illustrating by a cross-section diagram.

3. How far can 100 HP. be transmitted by a 3½-in. new, straight, smooth iron pipe, laid on a grade of 1 in 2,000, with a loss of head of 25%, under an effective pressure head of 750 lbs. per sq. in.?

4. A dock wall, plumb at the rear with a face batter of 1 in 24, is 20 ft. high and 9 ft. thick at the base (bottom of stream). The water in front varies in depth from 10 ft. to 18 ft. The masonry of the wall weighs 125 lbs. per cu. ft., and it is founded in earth weighing 112 lbs. per cu. ft. and having an angle of repose of 32°. Find the least depth of foundation required.

5. A wall is to be 20 ft. high and 4 ft. thick at the top to retain earth with a surcharge of 10 ft., having a slope upward from the top of the wall of 1 to 1, the natural slope of the earth being 45°. What should be the thickness of the wall at the bottom and the batter, if the back is to be vertical? Take the weight of the masonry at 130 lbs. and that of the earth at 120 lbs. per cu. ft.

6. Make an estimate of the total cost of excavating a ditch for a canal feeder, bottom width 5 ft., side slopes 1½ to 1, depth 6 ft., length 2¼ miles, through country approximately level. The soil for most of the distance consists of 3 ft. of sand and gravel overlying stiff clay, but for one-eighth mile the feeder will pass through a ledge of hard-shale and the slate that comes to the surface with a dip of 45°. The average overhaul is one-half mile and the time allowed for the work is 90 days. Give answer in detail.

(Sheet 2, for Levelers only.)

Directions.—In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full.

1. In order to find the quantity of water conveyed by a ditch 3 ft. wide, a weir with a rectangular notch 2 ft. wide and 1 ft. deep, with sharp edges, is placed across the ditch, causing the water to have a depth of 2¼ ft. above the bottom of the ditch, and 8½ ins. above the crest of the notch. Find the discharge in cubic feet per second.

2. What depth and bottom width should be given the transverse profile of a canal feeder, whose banks are of coarse gravel with a few weeds and slope at 40° to the horizontal, in order that it may conduct 75 cu. ft. of water per second with a mean velocity of 3 ft. per second? The feeder has a fall of 2 in 1,000.

3. A canal in clean coarse gravel is 20 ft. wide at the bottom, and its side slopes are 1½ to 1; it has a longitudinal slope or fall of 1 in 360 and a depth of 8 ft. If a submerged weir 2 ft. high be built across the canal, what will be the increase in the depth of the water?

4. The horizontal section of a canal lock has an area of 12,150 sq. ft. and the difference of level between the surfaces of the water in the lock and in the upper reach is 9 ft. Each of the two gates is to have one sluice or valve whose center is to be 20 ft. below the surface of the upper reach, and the water is to be leveled up in 2 mins. 48 secs. Determine the proper area of each valve.

5. A cast-iron beam of rectangular section, 12 ins. deep, 6 ins. wide and 20 ft. long, carries, in addition to its own weight, a single load P; the safe allowable tensile stress is 2,000 lbs. per sq. in. Find the maximum allowable value of P when it is placed (a) at the middle point, (b) at 2½ ft. from one end.

6. A hollow cast-iron pillar 12 ft. in height has to support a dead load of 35,000 lbs. and a live load of 20,000 lbs.; its internal diameter is 6½ ins. Find the required thickness of the metal, taking 6 as the factor of safety.

CIVIL ENGINEERING DRAFTSMAN.

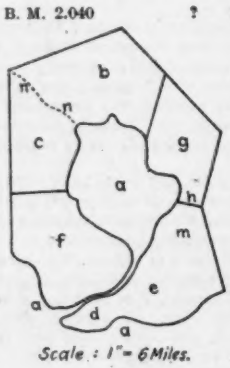
(Rating as follows: Examination, 7; experience and education, 3.) Time allowed for the whole examination, 8 hrs. The work of computation must be shown in full. Logarithm tables will be furnished by the examiner; no other books may be used.

1. It is required to find the distance from X to Y. X is inaccessible and cannot be seen from Y. The following data are given:

Course A B = 238 ft. bearing S. 87° 43′ E.
Course B Y = 317.5 ft., bearing N. 65° 17′ E.
Angle X A B = 46° 18′, angle X A B = 43° 29′ 30″.

2 to 4. Determine the quantities called for by the (?) in the following table of data from a highway survey. Find the cut or fill on the center line (c) of the survey; calculate the cross-section at each station, the amount of cut or fill in cubic yards between stations and the excess of cut or fill for the portion of the survey given (+ is taken to mean cut, and — to mean fill). The side slopes are to be 1½ horizontal to 1 vertical; the width of the road is to be 14 ft. on a fill and of excavations 20 ft.

Station.	B. S.	F. S.	Hgt. of Inst.	Elev.	Grade.	L.	C.	R.
T. P.	6.070	0.940	?	?				
6		0.97		?	104.15	11.75 / +1.15	?	12.48 / +1.65
5		2.11		?	103.22	11.1 / +0.74	?	12.32 / +1.55
4		7.59		?	102.30	12.4 / −3.60	?	11.8 / −3.20
T. P.	6.414	1.981	?	?				
3		1.67		?	101.37	8.95 / −1.30	?	7.9 / −0.60
2		1.15		?	100.44	11.3 / +0.85	?	11.5 / +0.95
B. M.	2.040		?	100				



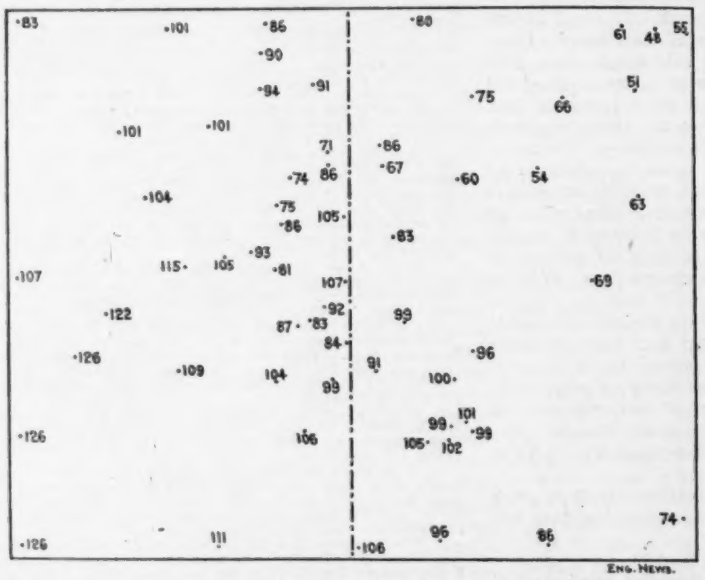
5—6. Copy the accompanying map to the scale 1 in. = 2 miles and in place of the letters, fill in the proper topographical signs to indicate

(a) water,
(b) marsh with stream,
(c) meadow,
(d) cliff,
(e) wooded hills,
(f) farm lands with roads and buildings,
(g) orchard,
(h) grove of evergreen trees,
(m) fallow or rough cleared land,
(n) willow and brush.

7. Draft the following title in letters of suitable sizes, using Stump or some other style of free-hand lettering that you can do neatly and rapidly: "List of Bench Marks and Other Notes of the Survey for the Construction of Canal Locks at Cohoes, New York."

8—9. Design a masonry and concrete dam for a stream 20 ft. wide with side slopes 1½ to 1. The water behind the dam is to be 12 ft. deep and in front 1 ft. The bottom is soft loam overlying hard pan at a depth of 15 ft. Make plan, elevation and transverse section drawings to suitable scale and indicate the method and materials of construction of foundation and superstructure.

10—11. Draw 5-ft. contour lines (at 90, 95, 100 ft., etc.) from the elevation points given on this sheet; mark the elevation of each contour and indicate the probable location of streams. From the contour sheet, when you have prepared it, draw on a separate sheet a section of the ground indicated by the line across the map, and indicate the vertical scale used.



ENG. NEWS.

BRIDGE DESIGNER.

(Salary, $1,500 to $1,800. Candidates must have had at least 5 years' practical experience in drafting, designing and constructing structural steel and bridge work. Logarithm tables will be furnished by the examiner, but no other books may be used in answering questions 1 to 5. Time allowed for whole written examination, 8 hrs.)

1. Discuss the arguments for and against the use of double and triple system trusses in railroad and highway bridge design.

2. Calculate analytically the stresses in a double system through Warren truss, 125 ft. long and 18 ft. deep of ten panels, each 12.5 ft. long, due to a uniform dead load (for each truss) of 800 lbs. per lin. ft. Place results on a truss diagram.

3. Determine graphically the stresses in a through bridge truss of 7 panels, each 27 ft. long, of the Pratt type, but with a broken upper chord, making the verticals respectively 29 ft., 35 ft., 38 ft., 38 ft., 35 ft., and 29 ft., due to a dead load of 1,200 lbs. per lin. ft., of which 400 lbs. is to be carried by the upper chord.

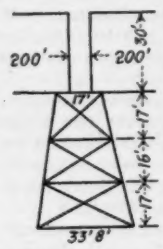
4. A through Pratt truss has 9 panels each 24 ft. long and 32 ft. deep. The dead panel load is 2.4 tons on the upper chord, and 5.6 tons on the lower chord, and the live panel load is 18 tons. Compute the maximum and minimum stresses in the fourth vertical and in the main and counter diagonals in the fourth panel.

5. Design, making plan, elevation and section drawings for a bridge pier, including its foundation on soil consisting of 2 ft. of silt and 10 ft. of sand overlying hardpan; the bottom of the trusses, each 140 ft. long is to be 35 ft. above the surface of the water, which is 9 ft. deep. By the proper conventional signs, indicate the materials of construction.

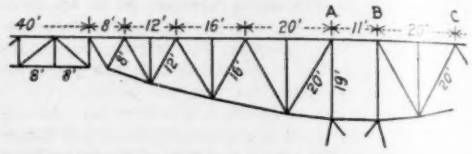
(In answering questions 6 to 10, any books of reference may be used. When formulas or constants are taken, give the book and page where they are found.)

6. Design a steel column 30 ft. high to sustain a dead load of 120 tons and a live load of 100 tons, without external bracing. Make to scale diagram of its cross-section and give all required computations.

7. A floor beam of soft steel in a railroad bridge has a span of 16 ft., and weighs 2,600 lbs. Each stringer is 22 ft. long and weighs 3,800 lbs. The stringers are spaced 7 ft. apart. The track is to be taken at 450 lbs. per lin. ft. The maximum floor beam reaction due to the live load is 46,600 lbs. The floor beam has a web 7-16-in. thick and an effective depth of 38 or 39½ ins. out to out. Compute the rivet spacing in the flanges. How many changes in rivet pitch would you adopt? Assume the proper working stresses.



8. The accompanying figure represents a pier, square in plan, supporting the ends of two deck trusses, each 200 ft. long and 30 ft. deep. The height of the pier is 50 ft. and is of three panels as shown. Ten square feet of bridge surface and ten square feet of train surface per linear foot are subjected to a wind-pressure of 40 lbs. per sq. ft. The center of pressure for the bridge is 68 ft. and for the train 86 ft., above the base of the pier. The wind produces also a horizontal pressure of 4,000 lbs. at each of the intermediate panel points on the windward side of the pier. Width of pier, 17 ft. at top, and 33 ft. 8 ins. at bottom. Dead load of bridge 1,600 lbs. per linear foot and live load 3,000 lbs. per lin. ft. Draw a diagram giving the wind stresses in all the members of the pier and indicate which are in compression and which in tension.



9. The above diagram represents one of a pair of cantilevers that support a free Pratt truss of 5 panels, each 8 ft. long and 7 ft. deep. The cantilever is made up of eight equilateral triangles of sides respectively 8 ft., 12 ft., 16 ft., 20 ft., 20 ft., 16 ft., 12 ft., and 8 ft., and a pier panel 11 ft. long and 19 ft. deep. Find the maximum stresses in the chords A B and B C, due to a live load of 600 lbs. per lin. ft. per truss crossing the bridge.

10. A deck plate girder bridge for a double-track railroad, span 120 ft., effective depth 140 ins., is to be designed in ten panels or sections of equal length. Find the shear and required web section in an end panel and the bending moment and required flange section in the fourth panel from one end for one girder due to live loads composed of two standard engines, described below, followed by a uniform train load of 3,600 lbs. per lin. ft. Pilot wheel loads, 18,000 lbs., driver loads 34,000 lbs., tender loads 21,000 lbs., from pilot wheel to driver 8 ft., four drivers spaced 5 ft. apart, drivers to tender 8 ft., four tender wheels spaced 5 ft., from tender to next engine, 8 ft., from second tender to train, 4 ft.

BRIDGE DRAFTSMAN.

(Salary, $1,200 to $1,500. Candidates must have had at least three years' practical experience in drafting on bridge and structural work. Rating as follows: Examination 6; experience, education and personal qualifications, 4. Logarithm tables will be furnished by the examiner; no other books may be used in answering questions 1 to 4. For questions 5 to 8 any books of reference may be used. Time allowed for the written examination, 8 hrs.)

1. In some neat, suitable style of free-hand lettering, write the title, "Design and Specifications for a Double System Warren Highway Bridge, Span 128 feet."

2. Find the web and chord stresses in a thorough riveted Warren highway truss of five panels, each 20 ft. long and 15 ft. high, due to a dead load of 10,000 lbs. per panel, 7,000 lbs. of which is to be taken by the lower chord and 3,000 lbs. by the upper chord.

3. The above bridge is to have a width in the clear of 18 ft. and the live load is to be taken at 96 lbs. per sq. ft. of floor. Design the floor beams and stringers and show how they should be attached to the other members of the bridge.

4. Design a suitable ornamental entrance for a through city highway bridge which shall be made of standard shapes or simple modifications, and shall serve also as portal bracing. Make detail drawings, if necessary, to show how this shall be constructed.

5. Design a deck plate girder, span 80 ft., depth 6 ft., which is to be one of two girders to support a highway span 18 ft. wide on which there may be a live load of 90 lbs. per sq. ft. Make plan, elevation and section drawings to the scale 1 in. = 4 ft., showing method of building up the girder, of attaching the lateral bracing, etc.

6. Give in detail the calculations for the determination of the flange area, allowance for rivets and number of rivets near the center of the above plate girder.

7. In a riveted Pratt truss of 9 panels, each 16 ft. long and 18 ft. deep, the following maximum stresses have been determined in tons, + meaning tension, — meaning compression. The stresses in the first five panels are, upper chord — 73.2, — 94.2, — 104.7, — 104.7; lower chord + 41.85, + 41.85, + 73.2, + 94.2, + 104.7; diagonals — 69.75, + 52.2, + 34.8, + 17.4, ± 0.3; verticals + 9.9, — 32.1, — 18, — 4.05. Design the members that meet at the lower panel point 48 ft. from the abutment. Make, to suitable scale, detail drawings of the joint at that point.

8. If the maximum allowable pressure in lbs., p, per linear inch of roller is 600 d, where d is the diameter of the roller, design the expansion rollers for a city highway span 120 ft. long with roadway 18 ft. wide in the clear and sidewalk on each side 4½ ft. wide. The dead load is to be taken at 780 lbs. per linear foot and the live load at 90 lbs. per sq. ft. of roadway, including sidewalks.

JUNIOR BRIDGE DRAFTSMAN.

(Salary, $900 to $1,200. Minimum age, 20 years. Rating as follows: Examination, 8; experience and education, 2. Time allowed for the whole examination, 8 hrs. No books are needed, and none may be used.)

1. In some neat, suitable style of free-hand lettering, write the title: "Design and Specification for a Double System Warren Highway Bridge, Span 88 ft."

2. A strong column about 1 ft. square is to be built up of standard shapes. Make a neat free-hand sketch to

scale of the cross-section of the columns, showing your method of building it up, having in mind simplicity of construction and ability to resist in all directions bending or "buckling." Calculate its weight per foot of length if the steel weighs 495 lbs. per cu. ft.

3. Design the end-post or diagonal for a through Pratt pin-connected truss. The length of the post is to be 32 ft., and it is to be 22 ins. wide and 15½ ins. deep. Make neat detail drawings, showing how you would build up the member from the standard shapes.

4. Make neat detail drawings of the connections at the upper end of the above end post.

5. The length of the upper chord of a Warren pony riveted city highway truss is 64 ft. It is composed of two angles 6" × 3½" × ⅝", two flats 3½" × 5-16", one web 14" × 7-16", two angles, 3" × 3" × 5-16", and one coverplate 14" × ⅜" × 35' 4". Make a cross-section sketch to scale and calculate the weight of the member if the steel weighs 496 lbs. per cu. ft.

6. The above riveted highway truss is to have a sidewalk, 6 ft. wide, outside one of the trusses. Make a section drawing, showing method of attaching sidewalk.

7. Make neat free-hand drawings showing the method of attaching floor beams and stringers for above bridge.

8. Design a suitable hand rail for the sidewalk of the above bridge; show method of its construction.

MECHANICAL ENGINEER AND DRAFTSMAN.

(Salary, $1,500 to $1,800. Candidates must have had at least five years' practical experience in drafting, designing and constructing shafting, gearing, chains, cables, pillow-blocks, etc., and such machinery as is used on swing bridges, lift bridges, locks, etc. Rating as follows: Examination, 6; experience, education and personal qualifications, 4. Slide-rules may be used and are preferred; logarithm tables will be furnished by the examiner. No other books may be used in answering questions 1 to 15. Time allowed for the written examination, 8 hrs.)

1. The valuation of the two expressions below is to be done by the use of the slide-rule, if you have one; if not, use logarithms. In putting down the answers, use four figures without counting zeros placed before or after the four figures. Explain your method of finding the location of the decimal point in the answers.

$$\text{(a)}\quad \frac{27.1 \times .356}{2{,}000 \times \dfrac{14.26 \times 98.5}{8.375}} = ?$$

$$\text{(b)}\quad \frac{2.225 \times 447.6 \times \dfrac{3.77}{.00402}}{\dfrac{1}{568} \times 54.6 \times \dfrac{9{,}080}{.0007975}} = ?$$

2. Explain the process, theory and effect of case-hardening soft steel. Why is it done? Why not use steel which can be hardened by simply dipping into water when red hot?

Explain the process, theory and effect of making malleable cast iron. Why it is used instead of ordinary cast-iron, or wrought-iron forging? What principle must always be borne in mind when designing a malleable casting which is not essential for an ordinary iron casting?

3. In the designing of steel castings as compared to ordinary iron castings, what four considerations and the reasons therefor must be borne in mind in order to secure satisfactory results in the foundry and a reliable product which can be designed to carry high unit loads?

4. Draw load-stretch (stress-strain) diagrams of the following materials, starting from the same zero point: Cast iron, soft steel, tool steel, non-homogeneous wrought iron, unannealed forged ductile material.

What is meant by "limit of proportionality" and "yield point," and what is their relation to loads which you would place upon machine parts?

5. Why are generously filletted corners more needed in forged steel than in wrought iron, and why are they needed at all?

Just exactly what is the difference between these two metals and the real cause for it, as regards this point?

6. What is the effect upon cold-rolled steel shafting of cutting keyways in it, or casting babbitt in a journal box around it?

7. Discuss the following materials from the standpoint of use for lubricated rubbing surfaces against forged steel: Babbitt, lead, iron casting, steel casting, bronze, phosphor bronze?

In what place is cast iron against cast iron an ideal material?

8. Given 4,250 lbs. and 21,670 lbs. as the working tensile load per square inch of cross-section of cast-iron and machinery steel respectively, with dead load, what would you use as unit working loads in the same place if you had repeated load? What if you had reversal of load? In other words, what is the influence of these three sorts of loadings upon the safe, allowable and desirable working fiber stresses which you would put upon machine parts?

9. Why are gears shrouded? In a swing bridge, should the pinion or rack, either or both, of the operating machinery, be shrouded, and why?

10. $\dfrac{R\ I}{e} = \dfrac{W\ L}{4}$.

Does this formula hold good for cast-iron beams at the moment of breaking, with the (R) as the ultimate tensile strength of the material as found in a tensile testing machine?

11. Describe what is meant by coefficient of friction, in language plain enough to be understood by a non-engineer, using actual figures in an illustrative example.

What is the proper value to assume for the coefficient of friction between two unlubricated, smooth steel plates?

What, if any, is the influence upon coefficient of friction of pressure, area of surface in contact, velocity of rubbing surfaces both lubricated and unlubricated, viscosity of lubricant, alternation of direction of rubbing, alternate application and relief of the pressure, slight axial freedom of motion, temperature range from 60 to 145° F., with pad or syphon lubrication or bath, or other excellent lubrication? Give reasons for the preceding.

12. Tell what you know about worm gearing. Under what conditions can it be advantageously used? What should be the design of the worm to secure maximum efficiency?

13. Sketch the six views of an object which has a definite base and front, and which is different on all sides (as perhaps a kitchen stove or an overhead rubber-neck traveling crane), and place each of the six views in its proper position relative to the front elevation, that is, in the commercial "angle" of descriptive geometry.

14. Draw the nine digits, also "one and five-sixteenths," as they should appear on the ordinary dimensions of a drawing.

Letter the following title free-hand with great neatness, with an ordinary writing pen, as it should appear in the lower, right-hand corner of a sheet of details about 18 × 24 ins.; no round writing permissible.

"DETAILS OF LIFTING MACHINERY FOR HECTOR BRIDGE, NEW YORK STATE BARGE CANAL. OFFICE OF CHIEF BRIDGE DESIGNER, ALBANY, NEW YORK. APRIL 27, 1904."

Letter the following note, to appear in connection with some detail on same sheet: "Changed to show four holes, only two of which will have bolts upon this bridge. 11-7-04."

15. A lift or elevator lock has water 15 ft. deep. It is intended to raise with its contained barge some 40 ft. Make a neat free-hand sketch showing a design and details for a tight-joint between upper fixed canal or approach to the lock and the vertical edges of the elevator basin. Describe clearly its method of operation.

What are the desirable qualities such a joint should possess? State the materials used for different parts, with of course the reasons therefor.

(In answering questions 16 to 20 any books of reference may be used. Logarithm tables will be furnished by the examiner, but it is preferred that slide rules be used instead. Give all formulas you use, with page and book from which you take them. State the books you have brought to the examination.)

16. Design an end-lifting arrangement for a small swing drawbridge, the arrangement being intended to lift 7,000 lbs. Calculate the principal parts of the arrangement and make a neat mechanical drawing of same with drawing instruments, triangles, etc., using pencil.

17. Given a rectangular, machinery steel column, ½ × 4 ins. in cross-section, 5 ft. long, pin and square, with pin at right angles to the 4-in. side of column, maximum working stress of 10,000 lbs. per sq. in., what is the working load which the column will carry? Give copy of formula. Why do you prefer this to the other column formulas as Rankine's, Ritter's, Gordon's, etc., that are in common use?

18. To find the dimensions and capacity of a double helical spring, of which the following is given: Outside diameter, 8 ins.; solid height, 5½ ins. Outside coil to be made of 1½-in. steel wire. Clearance between the two coils, 1-16-in. at each side. The spring should be 7⅛ ins. high when being used. Both coils have the same free and solid heights and are made of the same material though of different sizes.

19. A swing bridge is to be operated by electric motors running at 600 revolutions per minute. The radius of the circle of the rack, which is firmly anchored to the top of the pivot pier, is 15 ft. It is required that the bridge shall be opened 90 degrees in 1½ mins. against an unbalanced wind pressure, and in order to accomplish this the maximum force which must be applied at the rack is 11,000 lbs.

Calculate the size of the rack teeth, the size of the pinion and the shaft upon which it is mounted, assuming cast steel gears with cut teeth.

Make a diagram showing a possible arrangement of gears and shafting between the main pinion and the motor. What should be the electrical horse-power output of the motors?

20. A lift bridge is to be operated by two hydraulic cylinders for which a constant water supply will be given from the city mains at 87 lbs. pressure. The power required at the piston rod is 70,000 lbs. Calculate the size of the cylinder and the thickness of the walls. Make a neat sketch showing a desirable connection of piston rod to the lifting mechanism of the bridge. How should the piston be packed?

RODMAN.

(Salary, $3.50 to $4 per day. Rating as follows: Examination, 6; experience and personal qualifications, 1; education, 3. Time allowed for the written examination, 6 hrs. Logarithmic work and other computations must be shown in full. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used.)

1. The following is a well-known formula for weir discharge:

$$q = 3.33\,(b - 0.2\,H)\,[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}}].$$

Find by logarithms the value of q to three places of decimals when b = 5, H = 1.24, and h = .18.

2. A sand bank is 15 ft. high; the top is in the form of a circle with a radius of 5 ft; the bottom also is circular and measures 21 ft. across. Find the number of cubic yards contained in the bank.

3. In order to find the distance from A on one side of a hill to an inaccessible point W on the other side, a line 558 ft. long is run from A to B, and another 307 ft. long from B to C, from both of which W can be seen. The following angles are measured, A B W = 64° 17', W B C = 71° 37', W C B = 73° 54' 30". Find the distance from A to W.

4. A beam 12 ft. long rests across a narrow vertical wall at a point 3½ ft. from one end. The longer segment of the beam supports a weight of 64 lbs. at its outer end and the beam is kept horizontal by a rope from the other end which is fastened to the wall 3½ ft. from its top and the beam is kept from slipping by a cleat underneath it. Neglecting the weight of the beam, find the tension in the rope and the vertical pressure upon the wall.

5. From the following notes of the survey of a field, calculate the area in acres.

Course	Bearing.	Distance, ft.	Course	Bearing,	Distance, ft.
A to B	S. 69° 15' E.	706	D to E	S. 57° 45' W.	465
B to C	N. 37° 15' E.	593	E to A	S. 30° 00' W.	498
C to D	N. 39° 30' W.	000			

6. It is required, using a steel tape, to measure with great accuracy the distance between two points about two miles apart; mention and describe in detail the precautions that should be taken.

7. Mention and describe three methods employed or precautions taken to keep the subgrade of a macadam road dry. Why is it important that the subgrade be kept dry?

8. A trench for a canal feeder is to be dug, bottom 8 ft. wide with side slopes 1½ horizontal to 1 vertical. Suppose levels have been taken on the center line; explain in detail how you would set and mark the slope stakes.

9. What is meant by "ravelling" in a macadam road? Describe in detail the means that are employed to prevent and correct it.

10. In a survey two tangents (or courses) intersect at stake 112 + 45 and the deflection angle is 40° 30'. These tangents are to be connected by a 12° curve, which is to be located by offsets from the first tangent, the points to be determined for each 50 ft. of length. Find the first three offsets and the points on the tangent from which they are to be measured.

11. Describe in detail the best method of mixing by hand concrete for the foundation of a masonry retaining wall, and state the usual proportions of the ingredients.

12. State in their proper order and explain in detail the adjustments of the engineer's transit.

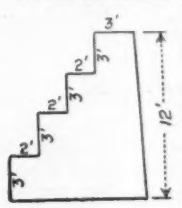
13. Plot the following stadia notes to about the scale 100 ft. = 1 in., and from the points when plotted draw contour lines for each even foot of elevation. Do not erase points plotted after drawing the contours.

Horizontal angle.	Distance.	Elevation.	Horizontal angle.	Distance.	Elevation.
36° 34'	79.68	116.48	126° 37'	185.26	122 92
39° 40'	159.36	119.77	103° 18'	175.65	115.13
83° 25'	99.40	118.96	88° 18'	199.60	119.19
156° 28'	45.91	110.47	61° 48'	220.56	120.34
147° 8'	65.93	112.60			

CHAINMAN.

(Minimum age, 18 years. Salary, $2.50 to $3 per day. Rating, as follows: Examination, 8; experience and education, 2. In solving problems the entire process and computation must be given on the answer sheet.)

1. Find the number of cubic yards of masonry in a dam 12 ft. high, 40 ft. long, with a front slope or batter of 1-in. to the foot and the back stepped off into three steps each 3 ft. high and 2 ft. wide; the top is to be 3 ft. wide 3 ft. above the first step. (See figure.)



2. A cylindrical tank or standpipe is 16 ft. in diameter and 40 ft. high. How many gallons of water will it contain if 1 gallon equals 231 cu. ins.?

3. A rectangular field contains 1¼ acres. It is 3¼ times as long as it is wide; find the dimensions of the field in rods.

4. A lot 100 ft. wide is to be divided into five lots of unequal width. Beginning at the narrowest, each is to be 1 ft. wider than the one before it. Find the widths of the five lots.

5. What will it cost to excavate a trench 8 rods 11½ ft. long, 5 ft. 8 ins. wide and 6 ft. 9 ins. deep at 37½ cts. a cu. yd.?

6. If the steel of which a surveyor's tape is made expands 0.00001082 of its length at zero for each degree increase in temperature, find the length of the tape at zero, if its length at 40.5° is 100.0308 ft. (Carry answer to nearest three places of decimals.)

7. Describe how, by the use of the chain alone, you would measure an angle in the field so that it could be mapped afterward.

8. Describe carefully how you would proceed if you were chaining your line down hill.

9. Explain how, by the use of the chain alone, you would lay out a course at the end of another course and at right angles to it.

10. If you are required to measure accurately with the chain the length of a course, what precautions would you take?

11. Explain how, by the use of the chain alone, you would lay off in the field an angle of 30°.

12. What advantages has the steel tape over the chain for accurate measurements?

CONCRETE FOUNDATIONS AND CEMENT FILLER FOR BRICK PAVEMENTS: A COMPARISON OF NATURAL CEMENTS AND PORTLAND.*

By O. L. Gearheart.†

About a year ago the writer made a series of experiments to determine the variation in the strength and cost of concrete due to a variation in the kind of cement and in the proportions of the ingredients.

The former practice was to use a natural cement concrete for the pavement foundation, but on one occasion a Portland cement concrete, consisting of 1 part Portland cement and 9 parts fine gravel, was used with excellent results. This led the writer to give the matter of Portland cement concrete further study. Tests were made with 8-in. and 6-in. cubes and beams 6 × 6 × 21½ ins. There were 11 different proportions with Portland cement and one with natural cement. An 8-in. and a 6-in. cube and one beam was tested after 30 days and 90 days. The specimens were made by the writer at the Champaign city laboratory, and, through the kindness of Prof. A. N. Talbot, were tested at the University of Illinois.

MATERIALS.—The materials used were Atlas Portland cement, Clark's Utica cement, gravel from a pit northeast of Urbana, sand from a bank in the same locality, and broken stone from a quarry at Kankakee, Ill. The sand was a fair quality of building sand, containing some clay and having about 35% of voids. Of the gravel, 23% was retained on a No. 4 sieve, 53% on a No. 10 sieve, 71% on a No. 20, and 29% passed a No. 20 sieve. It will be seen that the gravel con-

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors, at the University of Illinois, Champaign, Jan. 21.

†City Engineer, Champaign, Ill.

TABLE I.—Strength and Cost of Concrete of Different Compositions.

No.	Proportions (cement = 1) Gravel.	Broken stone.	Yield in terms of volumes of gravel and broken stone.	Age days.	Load on cubes in lbs. per sq. in. 8-in.	6-in.	Average crushing strength, lbs. per sq. in.	Beams, 6x6x18 ins. Load at center, lbs.	Modulus of rupture, lbs. per sq. in.	Cost per sq. yd. for depth of 6 ins., cts.
					Natural cement.					
1.	3	3	....	30	610	540	575	1,280	160	....
2.	3	3	77%	90	870	470	670	1,270	159	49.0
					Portland cement.					
3.	5	..	80.4%	30	1,750	1,565	1,657	2,700	338	77.5
4.	5	..	....	90	1,770	1,990	1,880	3,060	382	....
5.	4	4	74%	30	1,500	1,365	1,432	2,440	305	74.0
6.	4	4	....	90	2,210	1,780	1,995	5,380	670	....
7.	6	4	70.7%	30	1,180	1,170	1,175	1,800	225	68.6
8.	6	4	....	90	1,200	1,490	1,345	1,620	203	....
9.	5	5	74.4%	30	2,250	1,545	1,897	2,800	350	66.1
10.	5	5	....	90	1,850	2,050	1,950	3,280	410	....
11.	8	4	72.8%	30	890	840	865	1,650	206	57
12.	8	4	....	105	883	1,230	1,056	2,500	313	....
13.	6	6	70%	30	1,290	895	1,092	2,550	319	64
14.	6	6	....	90	1,510	930	1,220	3,060	383	....
15.	8	6	74%	30	965	570	767	1,750	219	56.8
16.	8	6	....	115	1,425	860	1,142	1,700	213	....
17.	7	7	74%	30	1,240	1,365	1,302	2,100	263	56.6
18.	7	7	....	90	1,190	1,425	1,307	2,820	353	....
19.	8	8	73%	30	1,010	990	1,000	1,600	200	51.4
20.	8	8	....	103	1,050	1,030	1,040	1,930	241	....
21.	10	10	71.5%	30	530	600	565	1,010	126	50.3
22.	10	10	....	118	585	.....	.....	1,220	153	....
23.	10	10	....	102	.....	610	.....	.....	...	....
24.	6*	6	....	30	1,230	780†	1,230	1,780	223	....
25.	6*	6	....	107	1,720	1,535	1,627	2,410	301	....
26.	8	10	70%	..	...	.....	.....	.....	...	51

* Sand. †Defective; omitted from average.

tained but little coarse material. The broken stone was a good quality of stratified limestone, crushed so that all of the particles would pass a 2-in. screen and be retained on a ½-in. screen. The stone is bought by weight, and on account of the freight charges, it is found cheaper to buy screened stone and fill the voids with a larger amount of gravel than would otherwise be necessary.

The cement was taken from bags shipped to the city for the retail market, and was not a special cement for testing purposes. It will be seen that the Utica cement is a very high grade of natural cement, and that the Atlas cement is a good quality of Portland. The fineness and activity of the cement are as follows:

	Utica.	Atlas.
Passing sieve No. 50.....	97.4%	99.6%
Passing sieve No. 100.....	80.5%	92.5%
Time, mixing to initial set.	32 mins.	1 hr. 56 mins.
Time, mixing to final set...	3 hrs. 20 mins.	5 hrs. 16 mins.
Tensile strength of cement, lbs. per sq. in.:		
Water	31%	17%
Age..... 24 hrs.	80	265
Age..... 7 days	181	710
Age..... 30 "	230	...

MIXING AND TESTING.—The cement and gravel were thoroughly mixed dry, then wetted and mixed into a stiff mortar, after which the dampened stone was added and the whole was turned several times. The mixture was then tamped into the molds by means of an 11-lb. tamper having a face area of 9 sq. ins. About two or three inches of loose material was placed in the molds at a time and tamped. During the operation a square-headed trowel was worked up and down between the concrete and the form, thus bringing the mortar to the sides and corners of the specimen and making it homogeneous throughout. Only enough water was used to cause a film of water to come to the surface after considerable tamping. The cubes were left in the molds for 24 hours with a damp cloth over them, after which time the molds were carefully removed and the specimens were stored under cloths which were dampened from time to time until the cubes were tested. The concrete beams were made and stored in the same manner as the cubes. In crushing the cubes and breaking the beams, the direction of the force applied was perpendicular to the tamped surface. Immediately before crushing the cubes, the two faces to which the force was applied was plastered with a thin coat of plaster of paris, and a self-adjusting plate was used to distribute the pressure over the entire surface of the cubes.

COSTS.—In arriving at the cost of the concrete, the gravel and sand were taken at 90 cts. per cu. yd.; broken stone, $1.40; Utica cement, 65 cts. per barrel; Portland cement, $2. The labor for measuring, mixing, placing, grading and tamping a 6-in. layer of concrete was taken at 6 cts. per sq. yd.

RESULTS.—Table No. 1 shows the strength of the cubes and beams and also gives the yield of rammed concrete in terms of the sum of the volumes of the gravel and broken stone. This table also shows the cost per square yard of a 6-in. layer of concrete of the different compositions.

CONCLUSIONS.—From the tests given it is believed that the following conclusions may be drawn:

(1) The cost of Portland cement concrete is about 4% more than natural cement concrete, while the former is 50% stronger (Tests 2 and 20).

(2) The strength of concrete composed of 1 natural cement, 3 gravel and 3 broken stone, and concrete composed of 1 Portland cement, 10 gravel and 10 broken stone, is nearly equal (Tests 2, 23 and 24).

(3) The addition of broken stone in amount equal to the gravel, without increasing the quantity of cement, materially increases the strength and decreases the cost of the concrete (Tests 4 and 10).

(4) The increase of the broken stone from 4 parts to 8 parts materially changes the strength of the concrete, but reduces the cost (Tests 12, 16 and 20).

(5) The increase of the broken stone from 8 parts to 16 parts does not materially change the cost of the concrete (Tests 18 and 26).

About half a mile of pavement having a very lean Portland concrete was laid during the past season under the writer's direction. It was found, much to the surprise of the writer and also of the contractor, that not only was the very lean concrete more easily mixed, but it was more uniform than the very rich natural cement concrete heretofore used. In all respects, the Portland cement concrete is superior to the natural cement concrete.

BRICK BEAMS.

The writer made a number of brick beams by taking paving brick and cementing them together with cement filler. The beams were 3 bricks long, 3 bricks wide and 4 ins. deep. They were formed by laying the brick side by side as in the pavement, and the interstices were filled with grout or filler consisting of 1 part Portland cement and 1 part sand. The cost of this filler was 8 to 12 cts. per sq. yd. Table 2 shows the result obtained by supporting the beams on knife edges 24 ins. apart and applying the load at the center.

TABLE II.—Modulus of Rupture of Brick Beams, with Cement Filler.

Items.	Brick. Clinton.			Culver.	Poston.
Age in days.....	30	30	90	30	122
Beams, 4" deep, 24" long:					
Breadth, ins.	10½	10¾	10¾	11	11
Load at center, lbs.....	1,640	2,160	2,660	2,570	2,210
Modulus of rupture,* lbs..	351	452	557	526	452
Beam span,† lbs.....	1,248	1,607	1,981	1,870	1,607

*Per sq. in.
†6 × 4 × 18 ins.; load at center.

By comparing (2) and (20) in Table I. with (3) in Table II., it will be seen that a brick beam 4 ins. in depth is 50% stronger than a concrete beam consisting of 1 natural cement, 3 gravel, and 3 broken stone, and is also a little stronger than a beam consisting of 1 Portland cement, 8 gravel and 8 broken stone. This fact suggests the idea whether it may not be more economical to employ the cement as a filler between the brick rather than using it in the concrete foundation.

The cost of the cement and labor for a 6-in. layer of concrete composed of 1 Portland cement, 8 gravel and 8 broken stone is about 24 cts. per sq. yd. more than that of a compacted layer of gravel or broken stone; and the cost of cement filler is about 6 to 10 cts. per sq. yd. more than sand filler. Therefore a brick pavement with cement filler on a foundation of broken stone or gravel without any cement in it is from 14 to 18 cts. per sq. yd. cheaper than brick pavement with sand filler and with a concrete foundation. And the two forms of construction are of equal strength.

For a pavement or street which has been cut up with trenches, and where the traffic is heavy, the use of the cement filler adds very much to the strength and to the life of the improvement, and the added expenditure for the filler is money well invested. In resident districts where the traffic is not so heavy or constant, a brick pavement with cement filler and a gravel foundation may be constructed with advantage, and the cost of the improvement be considerably less than if a concrete foundation and sand filler were used.

As far as the writer knows, attention has not before been called to the strength produced by the cement filler, nor to the fact that the brick thus filled makes the beam 5½ stronger than the use of concrete foundation; and in view of what has been said concerning the merits of the cheapness and strength of the cement filler, to use it in pavement construction is clearly an economical advantage.

For several valuable suggestions the writer is indebted to Prof. A. N. Talbot and Prof. I. O. Baker, of the University of Illinois.

FIG. 1. VIEW OF AUTOMATIC TIDE GATE IN THE BOLSA CHICA ESTUARY, CALIFORNIA.
(The gates have been purposely adjusted in various positions.)

AUTOMATIC TIDE GATES FOR THE BOLSA CHICA GUN CLUB, CALIFORNIA.

By Jas. D. Schuyler,* M. Am. Soc. C. E.

The readers of Engineering News may be interested in the details of construction of the automatic tide gates recently completed in the Bolsa Chica Estuary, some 35 miles south of Los Angeles. The Bolsa Land Co. owns some 2,500 acres lying along the coast, of which about 2,200 acres

*Consulting Engineer, Los Angeles, Cal.

are swamp lands, partly submerged at high tide with salt or brackish or fresh water, varying with the distance from the coast. It was desired to convert these swamp lands into the best feeding ground for wild ducks, as the property is leased by the Bolsa Chica Gun Club, for shooting purposes. To this end it was desired to reclaim the land sufficiently to keep salt water entirely out of it, and permanently lower and control the level of fresh water. A dam about 500 ft. long was built in 1899 across the estuary, connecting the high mesa with the sandpit along the ocean. This consisted of two lines of sheet piles, 20 ft. apart, held together with 1¼-in. ironrods, at intervals of 8 ft., where square piles were driven outside the sheet piling. The interior between rows was filled with sand to the top, which level is about 1 ft. above extreme high tide. A spillway 80 ft. wide was left in the center of the dam, closed

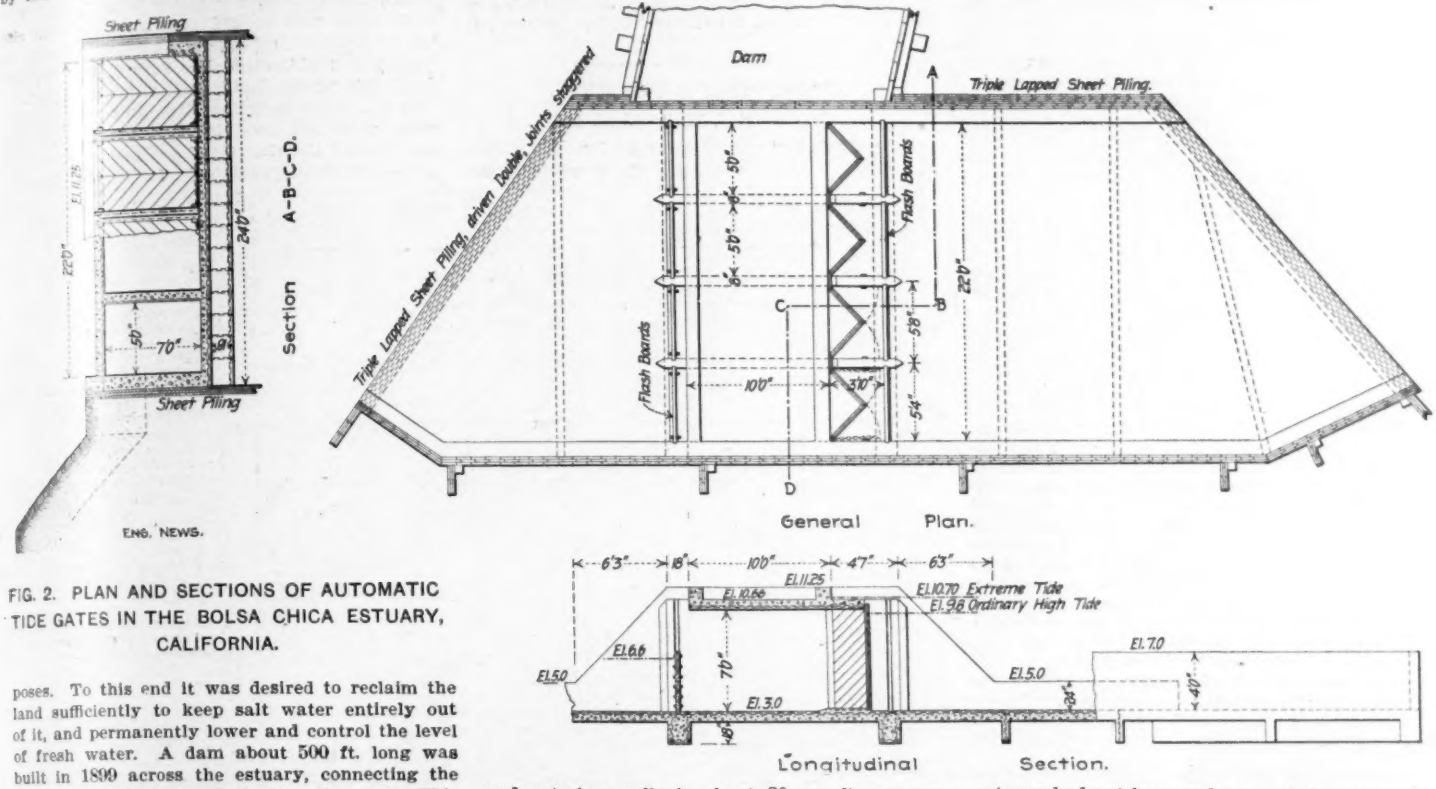


FIG. 2. PLAN AND SECTIONS OF AUTOMATIC TIDE GATES IN THE BOLSA CHICA ESTUARY, CALIFORNIA.

with heavy hanging gates. This spillway was not placed low enough to drain the fresh water pond to as low a level as desired to prevent flooding valuable celery-growing peat lands to the east. It was reconstructed at a little lower level two years later, using concrete placed in bags for the floor and wing walls. The leakage through, under and around this structure became very great, and although sand had been banked up on both sides of the dam, nearly concealing the woodwork, the rush of water through the leaks threatened its destruction. The volume of fresh water normally entering the marsh from drainage ditches and artesian wells is about 30 cu. ft. per sec., while that rising in springs throughout the swamps was roughly estimated at 40 cu. ft. per sec. additional. In the rainy season the fresh water discharge may at times reach 400 to 500 cu. ft. per sec., which must pass through the gates. In December, 1902, the writer was asked to design a spillway, with automatic gates that would be tight and permit of maintaining any desired level in the fresh water pond.

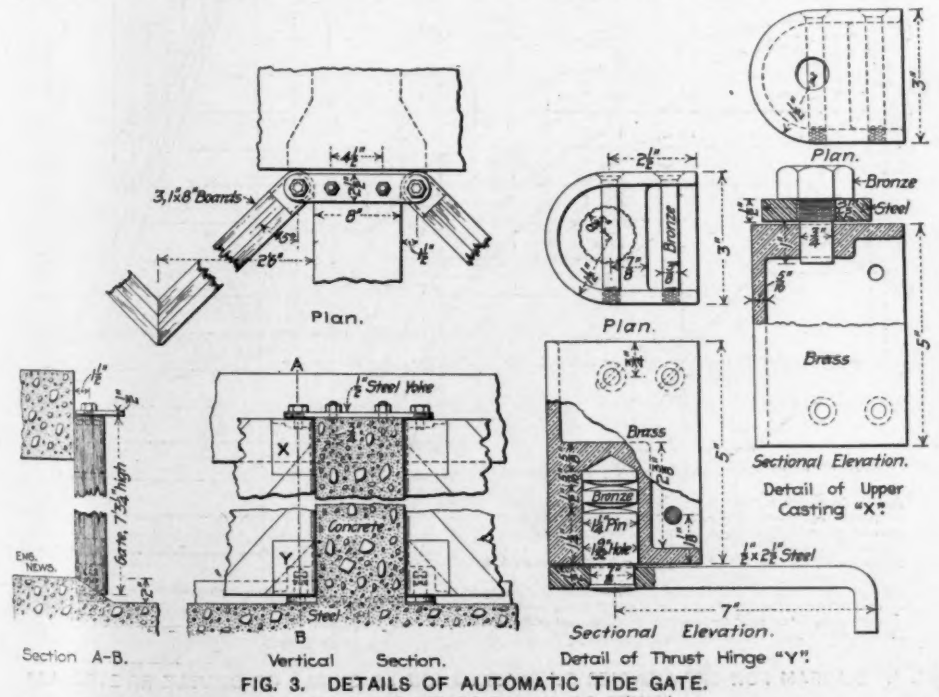


FIG. 3. DETAILS OF AUTOMATIC TIDE GATE.

The plans presented herewith were submitted and approved, and the contract for the work was let in January, 1903, but after the contractor had assembled all his material the work was peremptorily stopped by Capt. Edgar Jadwin, of the Corps of Engineers, U. S. A., on complaint of the farmers of the neighborhood that the dam was an obstruction to navigation, and an interference with natural drainage. This order was vacated by the Chief of Engineers after it had been shown that these representations were untrue, and the estuary had not been and was not then navigable, except for duck boats.

A second contract was entered into in April, 1903, and the work was finally finished in the following August. The gates operate with remarkable ease, and close with a current so slight as to be almost imperceptible. A view of the gates is shown by Fig. 1, and their construction is shown in detail by Figs. 2 and 3. The weight of the gates is supported on bronze buttons (Fig. 3), which means of support is equivalent to ball-bearings and very simple.

The following extract from the specifications describe the gate hangers in more detail:

> The gates will hang on bronze center pins, as shown upon the plans, with anti-friction buttons of bronze, which will form the principal step or bearing at the bottom and take the weight off the gate. Castings of bronze and wrought-iron hanger straps will be provided, as shown by the drawings, and embedded in the concrete or fastened to the gates in the manner shown by the plans and as directed by the engineer in charge. The gates are so designed that they will swing lightly and close as soon as the tide turns from ebb to flood, and they are designed so as to be easily removed for repairs. The bronze will be of a quality approved by the engineer, all smoothly finished, and free from blow holes or imperfections.

The gates do not leak an appreciable quantity and are quite satisfactory. The occurrence of quicksand in the foundation added greatly to the difficulties of the contractor in placing the concrete in the floor, but no leakage up through the floor could be observed with water standing 6 ft. higher outside. The entire structure is practically a monolith, bound together by iron rods embedded in the concrete at intervals of 18 ins. in each direction.

THE CACHE RIVER DRAINAGE SURVEY.

By A. H. Bell.†

A recent bill passed by the legislature of the state of Illinois provided for a survey of the Cache River in that state to ascertain the practicability of straightening and deepening the channel of the river for the purpose of preventing overflow of the bottom lands and for the drainage of these lands. The Governor appointed W. A. Wall, of Mound City; H. Kopher, of Marion, and A. Davisson,

*Abstract of a paper presented at the annual meeting of the Illinois Society of Engineers and Surveyors at Champaign, Ill., Jan. 20 to 22.

†Chief Engineer, Cache River Drainage Commission, Bloomington, Ill.

of Metropolis, to constitute the Cache Drainage Commission. They proceeded at once to select a corps of engineers to complete the survey.

The party consisted of one chief engineer, two assistant engineers, two chain carriers, two axe men, one teamster and one cook; and on Sept. 28, 1903, camp was made on the banks of the Cache River about two miles above its mouth at the Ohio River, between Cairo and Mound City. The work has been prosecuted with little delay, and was practically completed in January, 1904, so far as the actual survey at the channel is concerned. Some additional work will probably be done later on the watershed and tributaries. The survey was made up stream for the purpose of getting out of reach of back-water from the Ohio River as soon as possible. At the time the work was commenced it was not thought possible to complete it during the fall and winter, but the season has proven an exceptionally favorable one and the work has proceeded with but slight interruption. We have gone dry shod over many portions of the Cache River bottom which ordinarily are covered with water all through the year.

Commencing at the mouth of the Cache River, where it empties into the Ohio, with station "O," a deflection line was run by the transit man, setting station stakes at all curves of any importance on the channel and taking the deflection angles to the right or left as the case may be. To avoid any errors in angles, readings were taken from both verniers and recorded in separate columns; also the magnetic bearings of all lines were recorded. The transitman was followed by the chainman and leveler, who noted the surface levels at all stations; also frequent levels and cross-sections of the present channel. There were also made, upon several occasions, cross-section surveys of the entire bottom land adjacent to the river, to give some idea of its general contour and topography. These cross-section lines were run as nearly as practical at right angles to the general trend of the channel, and extended from bluff to bluff on either side. Levels were taken every 100 ft. The magnetic bearing of the line was noted, also the crossing of the general deflection line or channel survey. The stakes set at all angles of deflection were such as could be cut from the material at hand and were numbered consecutively from Station "O" up. The numbering of the stakes was done by one of the chain carriers with a wood scribe, the figures being cut into the wood to avoid any danger of erasure in the future.

We were provided with two tents, one 16 × 20 ft. and the other 12 × 19 ft.; also all the necessary camp equipage and a team and wagon to haul us to and from the work. The expense of the above was furnished by the state. All surveying instruments were furnished by the chief engineer. We aimed to work about three miles each way from camp before moving up the stream, thus making the camps about six miles apart. However, where roads were available we worked much farther, sometimes going as far as six miles each way, thus making our move a total distance of 12 miles.

The location of the deflection line was maintained by frequent ties to section and quarter-section corners along the line. The platting of the deflection line has been kept up with the field work all along, so that we would know at all times where we were and how things were coming out. Only so much drafting has been done in the field, however, as was necessary to intelligently prosecute the work; the balance will be done in the office after the completion of the field work. The completed maps will be on a scale of 1,000 ft. to the inch and will be drawn on ten separate sheets of paper. An additional map on much smaller scale will be made, showing the entire survey on one sheet. The maps will show all the meanderings of the present channel of the Cache River from the Ohio River to a point about seven miles northeast of Anna, Ill., which point is near its source. They will also show the levels along the Cache, cross-sections of the channel and river bottom, boundary line of land subject to overflow, and other topographical features obtained during the progress of the work.

In a general way only can certain information be surmised. That it is practical and feasible to reclaim nad drain the greater portion of bottom land adjacent to the Cache River is quite evident from the facts so far ascertained. The total length of the river by its meanderings will approximate 125 miles. By straightening the channel it could be reduced to near half this distance. The total surface fall at this time is 85 ft. The lower end of the Cache for 20 miles is subject to back-water from the Ohio; for this there is no remedy within reasonable cost. It is claimed, however, by property owners in the district that they do not care for the high water of the Ohio, for it comes at a season of the year when it is not detrimental to the farming interests; but it is then followed later on in the season by floods from the Cache River which render it useless. The bottom land ranges from ¼-mile to three miles wide.

The channel of the Cache is decidedly crooked in places, while portions of it (notably the lower Cache) would only need deepening. The upper Cache channel, through the counties of Johnson and Union, would have to be ignored almost entirely and a new straight channel constructed. Some idea of the work may be obtained from the accompanying map of a portion of the stream, which shows the meandering of the old channel and the line of the proposed ditch. The distance by way of meanderings of the old channel across is 5.44 miles; the proposed ditch line crossing the same territory would be 2.11 miles, thus shortening the distance 3⅓ miles. The entire bottom land adjacent to the Cache River is of good quality of soil, the best by far in that section of the state. Much of it is covered with timber and the lumber industry predominates along its course.

EFFICIENCIES OF RIVETED JOINTS.

By Gilbert S. Walker,* M. E.

In designing riveted steel work or calculating the strength of old work, it is the strength of the weakest part, the riveted joint, and not the strength of the body of the plate, that governs. It is found most convenient to express this minimum strength as a percentage of the strength of the body of the plate. This percentage is called the efficiency of the joint and the accompanying diagram is intended to lessen the work of determining its numerical value. The diagram will give the efficiency with as much accuracy as is warranted by the practical tests that are available. It is applicable to either single or double riveted joints, the ends of the plates being lapped over each other and riveted together direct or else butted together and covered by a single butt strap (single or double riveted to each plate); it is not applicable where double butt straps are used.

In the construction of this diagram the rivet holes were supposed to be punched somewhat larger than the rivets and not reamed, and their centers were supposed to be far enough from the edge of the plates to be in no danger of tearing out at the ends, say at least 1½ rivet diameters from the nearest edge. All other quantities involved, such as the ratios of the permissible tensile, shearing, and bearing stresses, the thickness of the plate, diameter of the rivets and pitch or

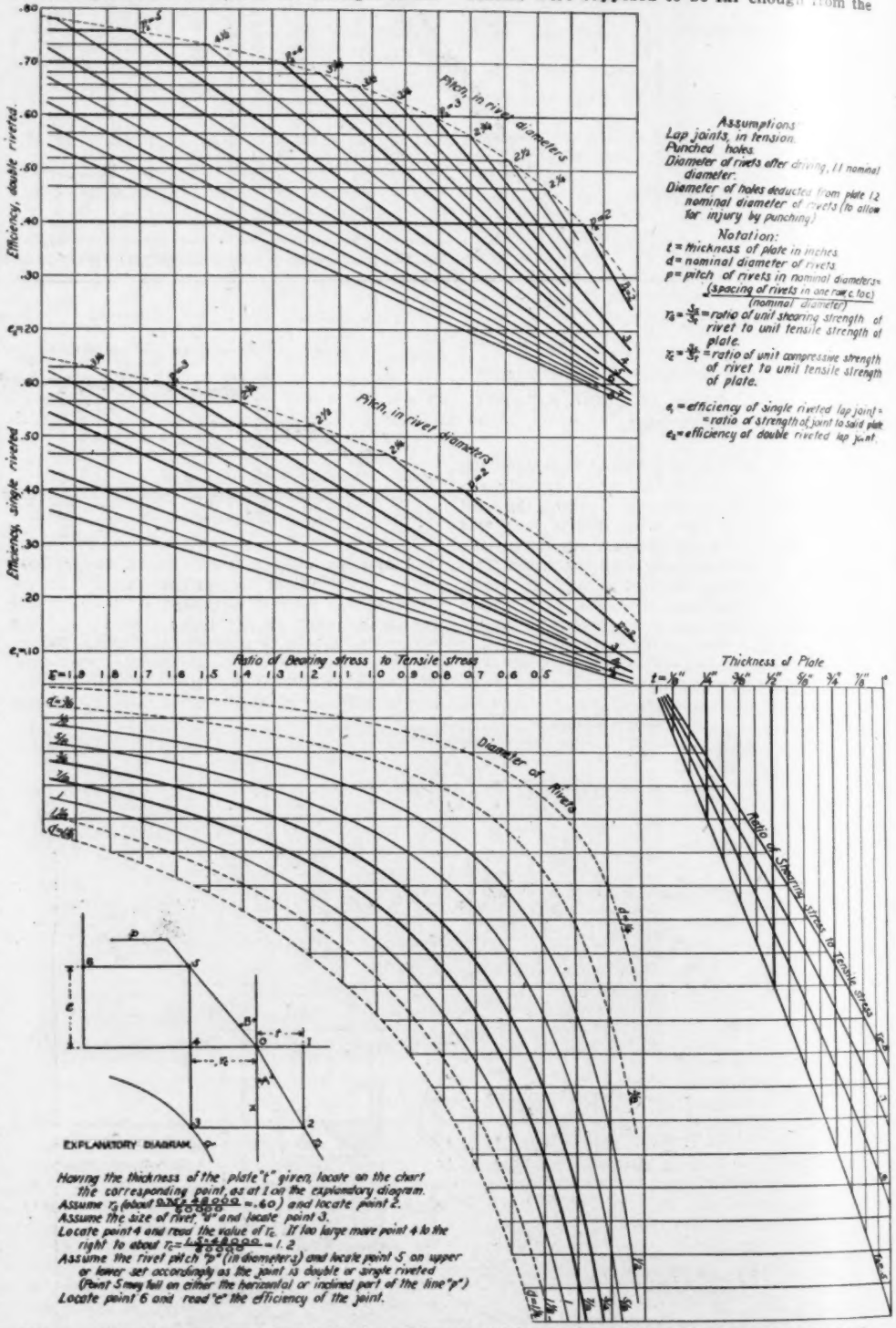

Efficiency, double riveted.
Efficiency, single riveted
Pitch, in rivet diameters
Ratio of Bearing Stress to Tensile stress
Thickness of Plate
Diameter of Rivets
Ratio of Shearing Stress to Tensile Stress
EXPLANATORY DIAGRAM.
Assumptions:
Lap joints, in tension.
Punched holes.
Diameter of rivets after driving, 1/16 nominal diameter.
Diameter of holes deducted from plate 1/8 nominal diameter of rivets (to allow for injury by punching.)
Notation:
t = thickness of plate in inches.
d = nominal diameter of rivets.
p = pitch of rivets in nominal diameters = (spacing of rivets in one row, c. to c.) / (nominal diameter)
r_s = 5/8 = ratio of unit shearing strength of rivet to unit tensile strength of plate.
r_c = 9/5 = ratio of unit compressive strength of rivet to unit tensile strength of plate.
e_1 = efficiency of single riveted lap joint = ratio of strength of joint to solid plate
e_2 = efficiency of double riveted lap joint.
Having the thickness of the plate "t" given, locate on the chart the corresponding point, as at 1 on the explanatory diagram.
Assume r_s (about 9,000 / 60,000 = .60) and locate point 2.
Assume the size of rivet, "d" and locate point 3.
Locate point 4 and read the value of r_c. If too large move point 4 to the right to about r_c = 1.5 × 40,000 / 60,000 = 1.2
Assume the rivet pitch "p" (in diameters) and locate point 5 on upper or lower set accordingly as the joint is double or single riveted (Point 5 may fall on either the horizontal or inclined part of the line "p")
Locate point 6 and read "e" the efficiency of the joint.

FIG. 1. DIAGRAM FOR EFFICIENCIES OF RIVETED JOINTS, SINGLE OR DOUBLE RIVETED; LAP JOINTS OR SINGLE-COVER BUTT JOINTS.

*1050 Main St., Wheeling, W. Va.

spacing of the rivets, may have any value that is practically suitable. By entering the diagram with these known values, the efficiency of the joint may be found without further calculation.

To explain the method of using the diagram a single example will suffice.

Suppose a stand-pipe 16 ft. in diameter is being designed and it has already been determined to use ¼-in. plating for the upper part. It is now to be determined how far below the surface of the water the pressure will necessitate a change to the next heavier thickness of plating. The strength of the joint in the plate is the determining feature.

The efficiency of the joint is found as follows: On the right-hand side of the diagram along the central base line find the thickness of the plate, ¼-in. Now from the grade of material to be used determine the minimum unit strength expected, say 60,000 lbs. per sq. in. tensile strength for the steel plates to be used and 36,000 lbs. per sq. in. shearing strength for the soft steel rivets; then

$$r_s = \frac{36{,}000}{60{,}000} = 0.6.$$

This ratio can of course be determined from the desired values of the working stresses instead of the ultimate strengths if more convenient. Starting on the diagram (at the right in Fig. 1) at the point t = ¼-in. just found, follow a vertical line downward until it intersects the diagonal marked $r_s = 0.6$. From this intersection follow a horizontal line to the left until it intersects the curve of a suitable size of rivets, say d = ⅝-in. From this intersection follow a vertical line upward noting as it passes through the base its reading $r_c = 1.30$ on the horizontal scale. This does not necessarily mean that the crushing stress on the rivet will be 1.30 times the tensile stress on the net area of the plate, for this will be determined entirely by the rivet pitch which may be chosen.

The desired value of r_c should, however, be obtained just as r_s was from the strengths of the grades of steel to be used, say

$$r_c = \frac{72{,}000}{60{,}000} = 1.20;$$

when the reading on the diagram comes out greater than this the vertical line being followed should be shifted over to the right and made to pass through the lesser value of r_c. Follow this line upward into the upper set of lines (assuming that double riveted joints are to be used) until it intersects the line of a suitable value of the rivet pitch, say $p_3 = 3¼$ diameters, or a rivet spacing of $3¼ \times ⅝ = 2^{1}/_{32}$ ins. From this intersection follow a horizontal line to the left-hand scale and read the efficiency $e_3 = 63\%$.

In selecting a suitable size and pitch of rivets it should be noted that:

1. When the reading on the base r_c is large, failure would occur by crushing, and a smaller size of rivets would give just as good an efficiency.

2. When the point 5 (see explanatory diagram in Fig. 1) lies on the horizontal part of the line p, failure would occur by parting through the line of rivet holes and a larger pitch would give a better efficiency.

3. When the point 5 lies on the inclined part of the line p and the value of r_c is small, failure would occur by shearing off the rivets and a larger size of rivets and a smaller pitch would give a better efficiency.

If, however, it is desired to find the size and pitch of rivets that will give the maximum possible efficiency proceed as follows:

Starting on the right-hand part of the base line at t = ¼-in. follow a vertical line down until it intersects the diagonal line $r_s = 0.6$ as before. From this intersection follow a horizontal line to the left until it intersects a vertical line through $r_c = 1.20$. The nearest rivet curve below and to the left of this intersection d = ⅝-in., is the size of rivets to use. From the point on the base line $r_c = 1.20$ follow a vertical line upward until it intersects the dotted line which passes through the knees of the lines p. Read $p_3 = 3.84$ by interpolating between the values of p_3 which are marked along the dotted line. The rivet spacing is found to be $3.84 \times ⅝ = 2.4$ ins. From this point $p_3 = 3.84$ follow a horizontal line to the left-hand scale and read the efficiency $e_3 = 69\%$.

In using this method it will be found that thick plates will call for very large rivets. Suppose, for example, that our plate had been ⅝-in. thick. Then following a vertical line from t = ⅝" down to its intersection with the diagonal line $r_s = 0.6$, and then a horizontal line to the left, its intersection with the vertical line through $r_c = 1.20$ will be outside the limits of the diagram and could only be fulfilled by rivets of unreasonably large size. In this case the horizontal line should be followed to the left only as far as its intersection with the curve of as large a size of rivets as is considered practicable, say d = 1-in., then follow a vertical line from this intersection upward through $r_c = 0.83$ to its intersection with the dotted curve through the knees of the lines p_3; read $p_3 = 3.03$ by interpolation and calculate the rivet spacing $3.03 \times 1\text{-in.} = 3.03$ ins.; then follow a horizontal line to the left-hand scale and read the efficiency $e_3 = 60\%$. This shows why it is so much easier to obtain efficient joints with thin plates than with thick ones.

But returning to the stand-pipe, suppose that it has been decided to use ⅝-in. rivets spaced 2 ins. c. to c. Then $p_3 = 2$ ins. ÷ ⅝-in. = 3.20. Find this point on the dotted curve by interpolation between $p_3 = 3$, and $p_3 = 3¼$; then follow a vertical line downward noting as it passes through the base line that $r_c = 0.91$, and follow it on down to its intersection with the curve d = ⅝-in.; then follow a horizontal line to the right to its intersection with the vertical line through t = ¼-in. At this intersection read $r_s = 0.42$ by interpolation between the diagonal lines. If neither r_c nor r_s exceed the desired values of these quantities then return to the point on the dotted curve $p_3 = 3.2$, and follow a horizontal line from it to the left-hand scale, and read the efficiency $e_3 = 62\%$.

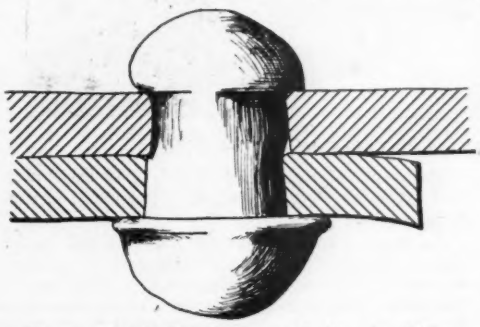


Fig. 2 Sketch Showing Irregularities in Driven Rivets.

If it is desired that the stand-pipe have a factor of safety of 5 then the tensile stress on the gross area of plate cross-section should be

1-5 × 60,000 × 0.62 = 7,440 lbs. per sq in.

The stress on the net area of the plate will then be

$$\frac{7{,}440}{0.62} = 12{,}000 \text{ lbs. per sq. in.}$$

the crushing stress on the rivets will be 12,000 × 0.91 = 10,920 lbs. per sq. in. and the shearing stress on the rivets will be 12,000 × 0.42 = 5,040 lbs. per sq. in.

The efficiency of the riveted joint having been found to be 62%, the maximum depth h below the water surface at which the ¼-in. plating can be used is easily found by an equation between the bursting force on a 1-ft. section and the resistance of the plates at the working stress.

In the preceding example much of the work of finding the efficiency of a joint has been repeated in several different ways in an effort to make the use of the diagram perfectly clear. The process may on this account seem somewhat more complicated than it really is. The explanatory diagram is intended to summarize the method of using the main diagram and serve to refresh the memory at any future time.

The use of the diagram in the design of riveted joints for other cases will not differ materially from the example given.

It has been attempted to make it of as general application as possible and to this end both single and double riveted joints are provided for by the two sets of efficiencies, etc., on the upper half of the diagram. The example was for double riveted joints, but the method is exactly the same for single riveted joints so that a separate explanation is unnecessary. Triple riveted joints usually have different rivet pitches in the different rows of rivets which makes failure possible in so many different ways that reduction to diagramatical form cannot be readily accomplished.

The diagram permits the choice within the limits of ordinary practice of any values of the tensile stress of the plate, crushing or shearing stress of the rivets, thus making it equally applicable whether the plating and the rivets are of the same or a different grade of material. It also permits the shearing stress to be taken at any desired per cent. less than the tensile stress and the crushing stress at any desired per cent. greater than the tensile stress for the same material. The exact relation between the crushing, shearing and tensile stress of steel is something about which there is wide divergence of opinion and very little reliable information.

The diagram is based on the assumption that the diameter of the rivets after driving will be 1.1 the nominal diameter before driving and the diameter of the rivet hole deducted from the plate to get the net area is 1.2 the nominal diameter of the rivet. This differs somewhat from the usual way of figuring rivets. The shearing value of rivets is sometimes figured on the nominal diameter and offset by using a unit shearing stress somewhat larger than warranted by tests, and sometimes figured on a diameter ⅛-in. larger than the nominal diameter. The actual diameter of the holes in excess of the nominal diameter will be found to be somewhat irregular in different shops, but is usually more in thick plates than in thin ones. Thick plates require considerable clearance between the punch and die to prevent binding, while thin plates require a very small clearance to prevent burred and ragged holes.

The accompanying sketch (Fig. 2) represents a rivet that would be passed by most inspectors. It shows that it is a waste of time to consider hundredths of inches in the diameter of rivets.

The deduction of still another tenth of a diameter from the plate is to allow for internal stresses and small cracks, on the supposition that the holes are punched and not reamed or annealed.

AUTOMATIC SPACING OF RIVET HOLES.

In fabricating structural steelwork one of the principal operations is punching the rivet holes. This is done universally by means of stationary power-driven punches. The location of the holes is previously marked on the piece of work with a prick-punch from a wooden strip or "templet" in which guide holes have been bored at the proper points. The piece of work to be punched, which may be angle, I-beam, plate or other shape, is drawn through between the jaws of the punching press, being stopped as a prick-punch mark comes exactly under the plunger of the punch; the latter is then thrown into action for one stroke by the workman stationed at the punch. Considerable skill is required to do this work accurately and yet with reasonable rapidity. Where two or more pieces are required with the same punching, each one must be marked and punched separately, each requiring the same amount of time and labor as if only a single piece were wanted.

In some special classes of work this method has been modified by the use of multiple punches, in which a number of separate punches, fastened to a common plunger and spaced in the desired arrangement, produce an entire group of holes at one stroke. The rivet holes in the ends of I-beams and channels, for standard beam connections, are made in this way in the best equipped bridge shops. This method applies of course to small groups of holes which are often repeated in the same arrangement.

Another method, adapted to long rows of holes, has been developed within the past two or three years, in the attempt to make the work of punching more accurate and more economical. This

method follows the same general procedure as in the usual method of punching, with the important modification that mechanical means are provided by which the piece of work is automatically stopped when the location of a rivet hole comes exactly under the punch. In this way the machine takes care of the accuracy of the location of rivet holes, and leaves to the workman only the care of feeding the piece through the machine and operating the punch; it is clear that much greater rapidity of working can thus be reached than is possible with the ordinary method of punching.

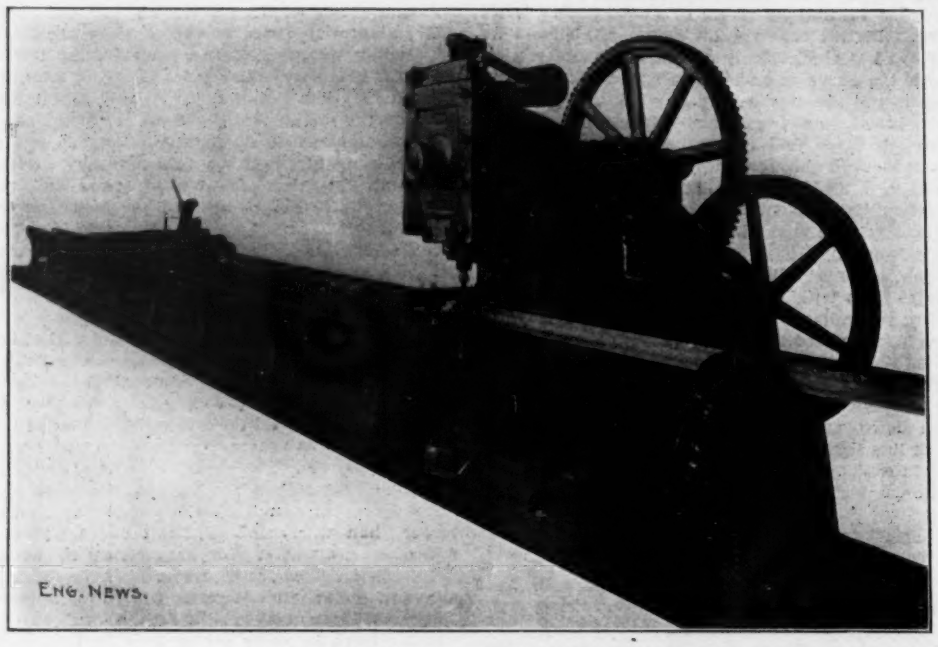


FIG. 1. CONLEY RIVET-SPACING TABLE IN OPERATION.

A simple machine for this purpose is the one shown in the drawings and views herewith. It comprises (1) a long table on the feeding-out end of the punching press; (2) a carriage traveling on this table and drawing the piece of work through the punch by means of a pair of gripping jaws on the carriage; (3) a series of dogs on the table, adapted to engage a latch projecting from the carriage, and thus stop the work; and (4) a lever for releasing the latch after the corresponding rivet hole has been punched. The photograph reproduced in Fig. 1 shows this machine in position behind a punching press, while a row of holes is being punched in one leg of a steel angle. Fig. 2 presents a front elevation of the machine, in working position, somewhat diagrammatic.

The table or track of the machine is made in sections, supported every 5 ft. on a leg frame. The carriage has a set of ball-bearing wheels by which it rolls along the top of the table; a second set of wheels bearing upward against the track prevents tipping. The gripping jaws and the lever by which they are operated are shown sufficiently clearly in Fig. 2. A small latch or bolt projects from the front of the carriage to engage the dogs, which are bolted to the front of the table and project above it. The bolt may be pushed back by means of a vertical lever, and is returned by a spring when the lever is released. The dogs are held against the front face of the table by a bolt fitted in a horizontal T-slot running the length of the table. The face against which they bear is grooved diagonally by V-grooves spaced ¼-in. apart. To secure exact adjustment of each dog, a screw projects from its bottom and bears against a ledge of the table; by raising or lowering the dog through this screw the dog is shifted laterally an equal amount, since it follows the diagonal (45°) grooves.

The only other element of the machine requiring description is the intermediate supporting roller and gear, shown at the right end of Fig. 2. This roller is normally below the level of the carriage, but as the latter passes beyond it, it engages and throws over the forked lever shown at the extreme right of Fig. 2, and thereby raises the wheel to the level of the angle or other piece of material passing through the punch, and furnishes a support for the piece. As the carriage is the only permanent bearing for the work on the feeding-out side, it is evidently necessary to supply temporary intermediate supports to prevent it from sagging under its own weight. For this purpose as many of these supporting rolls as may be desired are placed along the length of the table, usually one in each panel (5 ft.). The table may be built of any length desired, being made in sections for this purpose.

The manner of operating the machine will be obvious. The dogs are set at the proper spacing, as shown by the drawing of the work to be punched. The carriage is drawn along the table by a workman, who also releases the latch from the dog as soon as each hole is punched. The work is guided for gage by an adjustable roll on the punching press, which forms a rear bearing for the piece.

Two or three men are required for punching with the use of this machine: one at the feeding-in end, one at the punch, and one at the carriage. The punch operator also attends to setting the dogs, and must be a skilled workman.

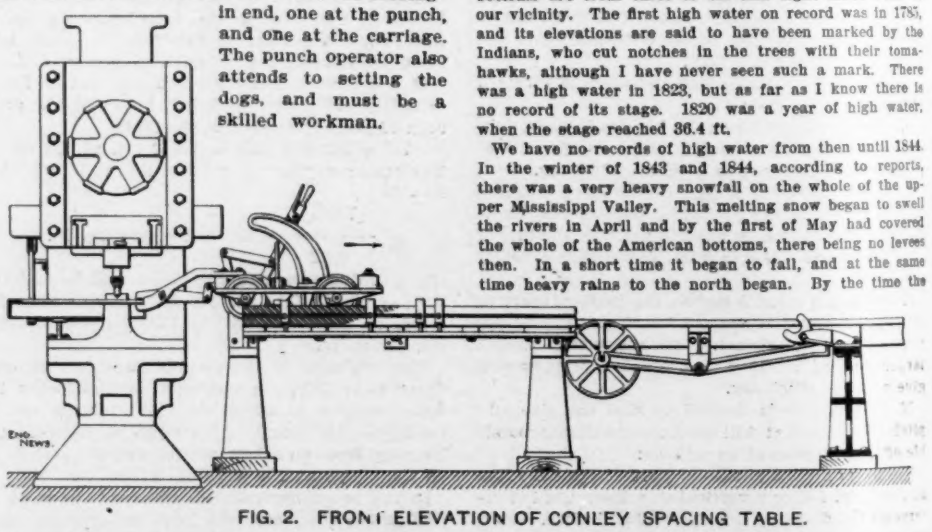


FIG. 2. FRONT ELEVATION OF CONLEY SPACING TABLE.

The machine, which is patented, is called the Conley Spacing Table. It has been in use in several bridge shops for some time. The full value of the device is realized only in work where a considerable number of duplicate pieces are required. When less than five or six similar pieces are to be made, little or no saving is realized, since the setting of the dogs then takes as much time as is required in the ordinary process of laying-out and punching. The J. W. Grove Co., Farmers' Bank Bldg., Pittsburg, Pa., control the sale of the machine.

FLOODS AND FLOOD PROTECTION WORKS AT EAST ST. LOUIS, ILL.*

By James F. Parr.†

The following paper relates to the experience of East St. Louis, Ill., during the flood period in June, 1903. East St. Louis and the neighboring towns of Brooklyn, Venice, Madison and Granite City, on the north (comprising a population of some 50,000 or 60,000), are situated on the east side of the Mississippi River in the great "American Bottoms" opposite the city of St. Louis, Mo. The snows of the Rockies begin to melt in April and by the first of June are beginning to flow by us and give what is locally known as the June rise. This rise itself gives a fair stage of water, and should there be excessive rains in the head waters to add to the June rise there is likely to be trouble.

Beginning on May 20, 1903, and for a period of 10 days, a series of storms passed over Kansas, Nebraska, Iowa, Minnesota, Wisconsin, northern Missouri and Illinois, flooding this territory and overflowing the banks of the creeks and rivers. At Sioux City, 2.7 ins.; at Des Moines, 2.18 ins.; at Davenport, 1.96 ins.; at Concordia, 1.74 ins.; at Peoria, 1.12 ins. of rain fell in a short time. This rain fell at such a time that by the time it reached the Missouri River it joined hands with the June rise and passed on down toward the Mississippi in time to join with the high waters coming down from the north.

Fortunately for the people living south of us, the Ohio was at a low stage, so that there was no flooded river below to retard the waters here. All along the river, levees that were considered as protections failed. All through the American bottoms are levees and cross levees and railway embankments built to hold these waters within bounds. At East St. Louis the Baltimore & Ohio Ry. enters on the north, coming in from the bluffs some six or seven miles east, and its embankments were built above the highest water known, that of 1844. South of us the farmers had built a levee, and in course of time the Conlogue Ry. took possession of this levee and is keeping it up for the use of it. East St. Louis is divided by Cahokia Creek, as shown by Fig. 1, and nearly the whole of that part west of it is occupied by railway yards and freight depots. The eastern part is the business and residence portion. On the creek is the depot, known as the Relay depot, from which the B. & O. Ry. levee leads out, and whose banks were a solid wall during the whole of the flood. This levee does not reach its full height until about one-fourth of a mile northeast of the Relay. From this high point south to the Relay and the Conlogue Ry. (one-half mile below the Relay), there is a levee some 4 ft. below the last high water. This stretch of three-fourths of a mile is where the fight was hardest. On the south of town and running to the bluffs is the Illinois Central Ry., whose bank forms a levee. Through the east part of town is a railway track known as the Belt Line, which track was used as a second levee.

As to high waters, there are unwritten records as far back as 1700. The effects of these past records are shown by the washings in the bottoms, where, in a number of cases, lakes are now left to mark their courses. These bottoms are from three to six and eight miles wide in our vicinity. The first high water on record was in 1785, and its elevations are said to have been marked by the Indians, who cut notches in the trees with their tomahawks, although I have never seen such a mark. There was a high water in 1823, but as far as I know there is no record of its stage. 1820 was a year of high water, when the stage reached 36.4 ft.

We have no records of high water from then until 1844. In the winter of 1843 and 1844, according to reports, there was a very heavy snowfall on the whole of the upper Mississippi Valley. This melting snow began to swell the rivers in April and by the first of May had covered the whole of the American bottoms, there being no levees then. In a short time it began to fall, and at the same time heavy rains to the north began. By the time the river was within its banks these rains began to pass by, and on May 20 another stage higher than the first swept by. The river had just begun to fall when another rain storm passed over the north, and on June 23 the water had reached a higher stage, and for five days stood high, reaching an elevation of 41.4 ft. on June 28. In this year the water receded very slowly. The next high water was in 1851, when, on June 10, the gage read 36.7 ft. In

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors, at Champaign, Ill., Jan. 20 to 22.

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1855 a reading was made of 37.1 ft. In 1858, on June 15, a stage of 37.1 ft. was again reached. On April 26, 1862, a stage of 37.45 ft. was reached. It was not until May 10, 1876, that a stage of 32 ft. was reached. Then, on May 6, 1881, a stage of 33.65 ft., and on July 5 and 6 a stage of 32.2 ft. On June 26, 1883, a stage of 34.8 ft. Then, on May 9, 1882, a stage of 36.0 was reached, this being a year that gave trouble, after which all levees were raised and strengthened. From that time until this the levees held, there being a stage of 31.0 on May 3, 1893. The above elevations are above a stage of 30 ft., which is here known as the danger line. The zero refers to a low-water stage in 1863, and at which time there was a stage of 10 or 12 ft. This zero gage is equal to an elevation of 378.07 ft. above mean gulf level at Biloxi, Miss.

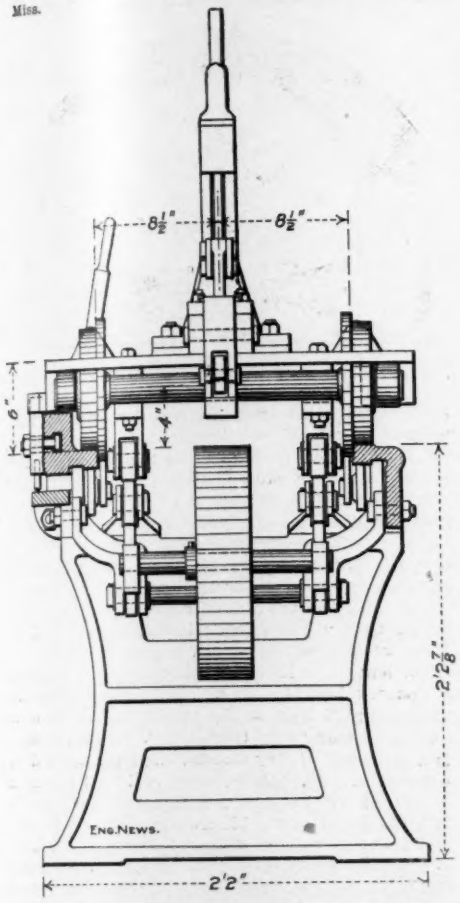


Fig. 3. Cross-Section of Conley Spacing Table.

The 1903 flood reached (on June 10) an elevation of 38 ft., the highest record since 1844. While the gage showed 38 ft., there was an elevation of 40 ft. at the Relay depot, and 41 ft. a mile further up on the north side of town. This is accounted for on account of the railway yards forming levees and the direction of the river, the city being on the back of the bend or outside of the curve. Our main street leading from the residence and business part to the river and to St. Louis was above the highest water and formed a dam to the water. The railway embankment leading to the Eads bridge, just above our main street and just below Relay, assisted in keeping the stage higher, there being only the river and Cahokia Creek to let the water pass through. In the short space of 700 ft., from the Relay south along Cahokia Creek, there was a fall of over 1 ft. in the current of the water. Nearly all the railway yards between Cahokia Creek and the river are at right angles to the river, and as the water rose the one farthest to the north was the first to be submerged, and then in a short time all were broken through or else overflowed. These yards are all made over what was once a secondary channel to the main river. All of the yard tracks cross Cahokia Creek on trestles, except the Vandalia and Terminal lines just below the Relay, which cross on plate girders with masonry abutments and somewhat narrow up the creek. There was more or less drift in the creek and this added to blockade the passage of the water. As the water came over these yard tracks it caught a small house just above the girder bridge mentioned and lodged it at this opening, which was probably the cause of the greater depth at the Relay and also the great fall mentioned.

As to the emergency protection methods used, it was at first intended to use these yards by raising their embankments, but it was soon found that that would not do, as the river was rising at a rate that indicated their submergence in a short time. That part of the town west of Cahokia Creek was abandoned and preparations were begun for a levee along Cahokia Creek by means of sacks filled with sand, gravel and clay placed along the points of danger. These sacks were laid at right angles to the water and the clay was thrown on the water side to prevent seepage. Then as the water rose a second row of sacks was placed inside of these, some 2 to 3 ft. being left between the two rows. This space was then filled with clay and then a second layer of sacks were placed on the first row and then more clay filled in. In the meantime the levee was kept above the rising water. Where possible, the sand was used to fill sacks and clay reserved for intermediate filling. This levee was built on top of some of the yard tracks running parallel to the creek and so close that dirt was plowed from the trains by means of a steam plow upon and over the sacks laid. This saved a second handling of the material.

The train of sand stood on a track near the emergency levee and was kept full of men filling sacks, which were carried to the place needed. Nearly all of the yards were emptied along the temporary levee so that they could be used for storing trains of sand and clay for raising the levee. It was fortunate that the World's Fair was building, as the steam shovels used for leveling the hills there were kept loading dirt trains for the protection of East St. Louis until the water got so high that trains could not be brought over by he Terminal R. R. Association. They ran trains in 3 to 4 ft. of water, and men had to use their feet to find the switch lever in order to throw it. One train was being wrecked on tracks 4 ft. under water within 100 ft. of where needed, because of the inability to properly throw the switch or to see that it was clear after being thrown. The Illinois Central Ry. ran trains to the bluffs (Fig. 2), where men were kept busy loading dirt, which was used on the south end of the levee. The Louisville & Nashville Ry., whose yards were on the inside of and adjoining the levee, kept trains busy loading dirt and hauling from the bluffs. The roads entering from the north lent assistance until they were cut off by the water. The St. Louis, Belleville & Suburban Electric Street Ry. lent valuable assistance after other roads were cut off, as well as before.

After some of the roads were cut off from the bluffs, dirt was taken from the inside of the city limits and on private property. As fast as sacks were laid the earth was kept tramped by continual passage of men carrying sacks forward to other places. Sacks were laid at the foot of the railway embankments and carried up to the slope, and then up with the rise of the water. This was found necessary because of the cinder filling used in the original raising of the side and main tracks. More caution was used at night than in the day time, from the fact that the torches carried showed the seeping of the water plainer, and to some extent exaggerated the size of the seepage streams. I often noticed that seepage being watched in the day time did not exercise the minds of the watchers as strongly as it did by night.

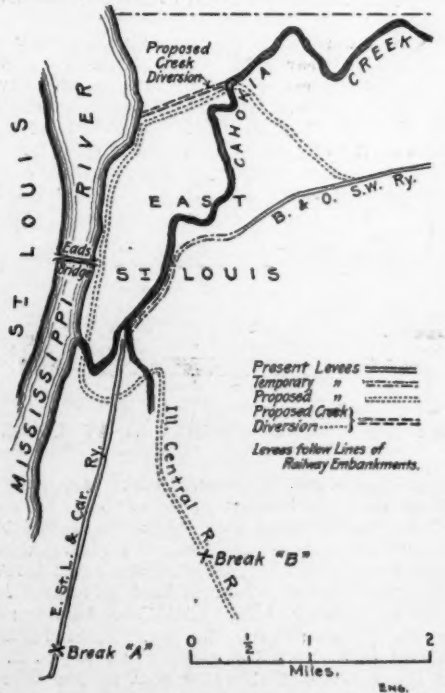


Fig. 1. Map Showing Existing and Proposed Levees at East St. Louis, Ill.

The first break occurred some three miles below the city (A, Fig. 1), and began to fill that territory. Then the Illinois Central Ry. embankment became a secondary levee on the south, and that was guarded until a break (B) nearly at the last moment flooded the southern part as far as Broadway. This street being elevated, formed another levee in conjunction with a track on the east side of town. This break occurred at an old filled spot. The backwater, on account of the break being below, did not rise as high as the river by some 4 ft., and the majority of the town was left dry. After the water reached Broadway from the break it began to slowly work its way through it by means of the laterals to the sewer, and later by a break in the Broadway sewer. By this time the river began to fall and the seepage through this street did not rise as high as the back-water. Some of the cross streets in the business part of the town are made of sand from the river, and when the seepage water rose high enough it softened them and they went to pieces. They were built with a slope of 1½ to 1 and were paved with brick. As soon as possible after the river began to fall men were put to work opening outlets for the water to escape. All sewers had been stopped by filling them with sacks of sand to keep the water from backing in through them. It was a task far harder to remove these sacks than to place them in the manholes of the sewers, these sacks often being torn to pieces when removed.

As East St. Louis has to pump the sewage at certain stages of the river, and as two of the pumps were stationed where they became inoperative after the river rose, after the break it left the city with only one pump to remove the sewage and back-water. As soon as possible a fire engine from St. Louis and one from Belleville was obtained and water pumped out by means of fire hose without nozzles. Our only pump was removed to a better location, and water pipe borrowed from the water company was laid on top of the ground and the water

Fig. 2. Map of Proposed Flood Relief Canal for the Protection of East St. Louis, Ill.

pumped out in this manner over the top of the temporary levee. As the back-water was always lower than the river, as the river fell it was some time before the outlet sewers could be opened, because of the danger of the water pushing in instead of out. Levels were taken every day, and as soon as the river fell below the elevation of the back-water, all outlet sewers were opened and assisted the pumps in removing the back-water, the flooded pumps being put in operation as soon as possible. The breaks in the levees, while flooding the lower part of the town, did not carry the water out as fast as it came in, and in time the river dropped below this back-water.

There are several methods suggested for the prevention of floods in the future. One is to build a levee from Alton, Ill., on the east bank of the river, as far down as will be sufficient to protect the whole American bottom, including farmers, as well as towns and cities. This proposition will necessitate flood gates at the outlet of all creeks, with pumping plants to be used in times of high water. On the whole, I am inclined to think this the best plan. A plan was suggested previous to this flood, and has been suggested again, to change Cahokia Creek above the city and turn it into the river above, and use the dirt excavated therefrom to make a levee on the south side of the creek, as shown in Fig. 1, From where the creek is to be changed there cross two belt line railways running parallel and 100 ft. apart from the creek to the B. & O. Ry. These are to be raised above the high water and the space between them filled in. If this is done it will give along the belt tracks a levee about 100 ft. wide on top. From this intersection to the bluffs, the B. & O. Ry. bank is high enough, but it is suggested that it be strengthened. The Vandalia Ry. runs along the north side of and parallel to the B. & O. Ry., and in the present high water it was under water. It has been suggested that the Vandalia bank be raised

above high water and that the space between it and the B. & O. bank be filled in. If this is done it would give a solid levee on the north of 100 ft. wide from the river to the bluffs. It would necessitate a levee being raised several feet above any previous high water, as such a levee running almost at right angles to the river would form a dam, with the river as the only outlet.

From where the proposed change of the creek empties into the river it is intended to raise Front St. (which runs parallel to and on the river bank) and the railways that occupy the river front between Front St. and the river to a height above any possible overflow. This front levee is to be carried south to the extreme southern part of the city, where the railway yards are, and then to follow this track to where it crosses the Illinois Central Ry., and then to follow this railway to the bluffs on the south. A part of this proposed levee on the river front is in working condition now, but does not extend far enough north or south. The Illinois Central Ry. has two tracks running parallel and 100 ft. apart, which now form good levees. It is suggested that these be raised and the space between them filled in. If these suggestions were carried out it would give East St. Louis an independent levee system.

Another proposition is to make a new channel for Cahokia Creek from where it leaves the bluffs, and to follow the bluffs far enough south so that no back-water would rise high enough to overflow the land. The earth excavated from this channel is to be thrown on the side opposite the bluffs to form a levee, and flood gates to be placed in this levee to prevent inflow from any back-water. This proposition would do away with the creek through or above East St. Louis, and would turn any overflow of the river east of it.

Another plan, shown in Fig. 2, is to excavate a canal from the junction of the Missouri with the Mississippi, east to the bluffs, and then along the bluffs south and uniting with the Mississippi some 20 miles below East St. Louis. The material from this canal would form a levee on the south and west sides, and so make an island of the present city of East St. Louis. This canal would be 200 ft. wide and deep enough to float barges. It would necessitate the raising of all railways at the bluffs, but as they now have to climb them it would only lengthen their distance of incline, giving a better grade; or else place them higher up so that better advantage of the hills might be taken. The levee might be used in a double way: as a public thoroughfare or boulevard, and for a belt line railway transferring freight for through points on the various roads that cross it. The property adjacent to the levee could be used for manufacturing sites, as there is plenty of coal in the bluffs. It is claimed that this canal would so enhance the value of the property benefited that no higher tax rate would be necessary.

A smaller proposition, which includes only the residence portion, was voted for on Dec. 15, and carried by a small majority. It was considered by a great many not to be the proper method, as it leaves exposed nearly all the railway yards which were giving employment to so many. As the law only allows assessment to be made on property benefited, they claimed that there would not be taxes enough raised to properly build such a levee. A number who voted against the proposition would have voted for a proposition to levee the whole city. Out of a vote of over 7,000 not one-half voted. As this vote was not ratified by a two-thirds majority of the city council it failed to pass.

The estimated loss has been placed at from $1,500,000 to $2,000,000 in railway property, city property and the temporary throwing out of employment of men working in the different factories that were closed. The cost to the city in building this temporary levee has been placed at $70,000. The loss to the railway was in the overflowed tracks and washouts in the yards and loss of business during the flood; to the city, in the destroying of streets and pumping plants; to citizens, in the overflow of their household goods, and to business houses, in the loss of goods in basements, as well as to the general interference with business.

While it may seem strange, it is nevertheless a fact that the flood was to a certain extent a benefit. It washed and floated away a great amount of decaying matters thrown in alleys and open fields. It might be supposed that sickness would follow, but such was not the case. One reason was that all was put in good order before being occupied again, and there was no stagnant water left to breed any kind of disease.

THE WEAR OF SEWER INVERTS.

By E. A. Hermann,* M. Am. Soc. C. E.

The inner bottom surface of a storm sewer, generally called the invert, is subjected to considerble wear by the constant flow of sewage and the gritty substances, such as sand, gravel and stones, washed into the sewer through house and yard connections, grated manhole covers, or sewer inlets placed at street intersection corners for the surface drainage due to rainfalls.

This wear is confined almost entirely to that part of the surface of the invert covered by the ordinary foul water flow, the balance of the sewer receiving practically very little wear from the occasional increase in the depth of the discharge of the sewer. The width of this wear is generally not over 1 or 2 ft., and rarely exceeds 4 ft.; it depends, of course, upon the quantity of the ordinary foul water flow. It follows, therefore, that the part of the invert covered by the ordinary foul water flow should consist of a wearing course much harder than the balance of the sewer. This is impracticable for vitrified clay pipe sewers, but it can be done, at very slight additional expense, in sewers of brick, stone or concrete construction, and it is important that the sewer shall not be dangerously weakened or destroyed by the constant flow of sewage wearing deeply into or through the invert.

Separate sewers have a comparatively small discharge and receive very small quantities of gritty substances, and consequently the wear of the inverts of such sewers is very slight; but combined sewers have a large discharge and receive large quantities of such gritty substances as above mentioned, and the erosion of the inverts caused thereby is an appreciable quantity and often a seriously destructive agent. The amount of wear depends upon the hardness and smoothness of the material of construction of the sewer, upon its ability to resist the disintegrating action of the acids in the sewage, and upon the grade of the sewer. The materials most commonly used for sewer construction are vitrified clay pipe, vitrified brick, common building brick (more or less mard-burned), and concrete.

In the sewers of the city of St. Louis, which are on the combined system, the grades range from 0.2% to 2%, averaging about 0.5% for sewers more than 5 ft. in diameter and about 1% for the smaller sewers. The vitrified clay pipes show no appreciable wear after about thirty-five years' use; these sewers are mostly laterals, and have, of course, the smallest discharge, though some of those in the business and manufacturing sections of the city carry a constant stream from 1 to 3 ins. deep, containing more or less acids, scalding hot water and steam. The pipes vary from 12 to 24 ins. in diameter, except a few lines, which are 30 and 36 ins. in diameter.

The vitrified brick also shows no appreciable wear; it has, however, been in use only about twelve years. One course of square-edged bricks (building foundation vitrified bricks) are used for the lower quarter of the circle of round sewers; in sewers of other forms the vitrified bricks are carried to a line 6 ins. higher than the surface of the ordinary foul water flow in the sewer. The balance of the sewer is built of common hard-burned building bricks. This form of construction provides a wearing course for the invert of a very hard, smooth material, unaffected by acids, and covering that part of the sewer subject to constant scouring action.

The inverts of sewers built of common brick begin to show some wear after about three years of service, and after about thirty years' use the first ring of brick is worn away from 2 ins. to nearly its whole depth of 4 ins. This wear varies greatly in sewers of different size, grade, quantity and quality of sewage, and hardness of brick; the average life of such brick appears to be about forty years.

In St. Louis several miles of wornout inverts have been replaced within the last dozen years by vitrified brick, and it is confidently hoped and expected that the new inverts will outlast at least three of the old ones. All new sewers have inverts of vitrified brick, as described above. The wear of the common brick inverts is shown in longitudinal and cross-sections by Fig. 1; this wear is very rough and irregular, due to the varying hardness of the bricks and the eddies and deflecting currents caused thereby. The resistance to the flow of the sewage is evidently greatly increased; it is quite noticeable to the eye in the swift smoothness of the current where a new section of vitrified brick adjoins an old section of common brick much worn, but not yet deemed worn out. The method of replacing the wornout invert with vitrified brick is also shown by Fig. 1. A section of the sewer, averaging about 150 ft. in length, is laid dry and bare by building a temporary dam at each end, and providing for the uninterrupted flow of the sewage by means of a flume extending over these dams. The lower dam is a thick roll of clay puddle, only; the upper dam consists of 2-in. boards, supported by large nails or spikes (or bars in the large sewers), driven into the joints of the brickwork of the sewer, and made watertight by means of clay puddle placed against the upper side of the dam. The old wornout bricks are loosened with picks or iron wedges and removed, and after the new vitrified bricks are in place, the mortar is allowed to harden for at least 48 hours before the dams are removed to the adjoining section, where the process is repeated. The nearest manhole below the dams serves as the point of ingress and exit for men and materials. None but the best brands of Portland cement are used for the mortar, both for vitrified and common bricks.

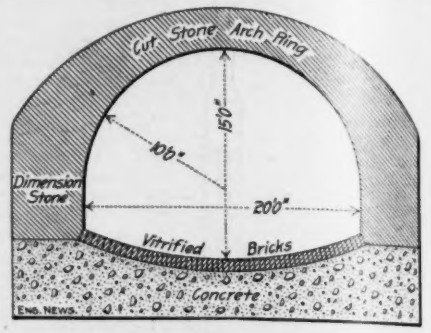


Fig. 2. Section of Large Sewer at St. Louis, Mo.

In the reconstruction of the invert of a large sewer (15 × 20 ft.; see Fig. 2) in St. Louis, about eight years ago, concrete was used both with and without a covering of vitrified brick in adjoining sections of the sewer. The sections covered by vitrified brick are by far the most satisfactory; the surface is smooth and hard, and no appreciable wear can be detected. The surfaces of the concrete sections not covered by vitrified brick, that is, where the surface of the concrete is directly exposed to the sewage, is completely pitted with small holes varying in size from ¼ to 1½ ins. in depth and area. The Portland cement mortar between the stones of the concrete seems to be partially disintegrated, leaving a very rough surface of projecting stones. When new, this concrete was allowed to harden for several days before the sewage was permitted to flow over it. The cause of the pitting has not yet been determined; it may be due to the effect of the acids from decomposing organic matter, acids from manufacturing establishments, or other causes; the effect, however, is plainly evident, and the inverts of all new sewers of this or similar kind are now being covered with a wearing course of vitrified brick.

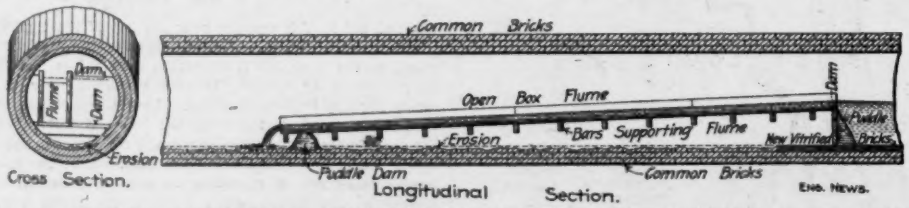
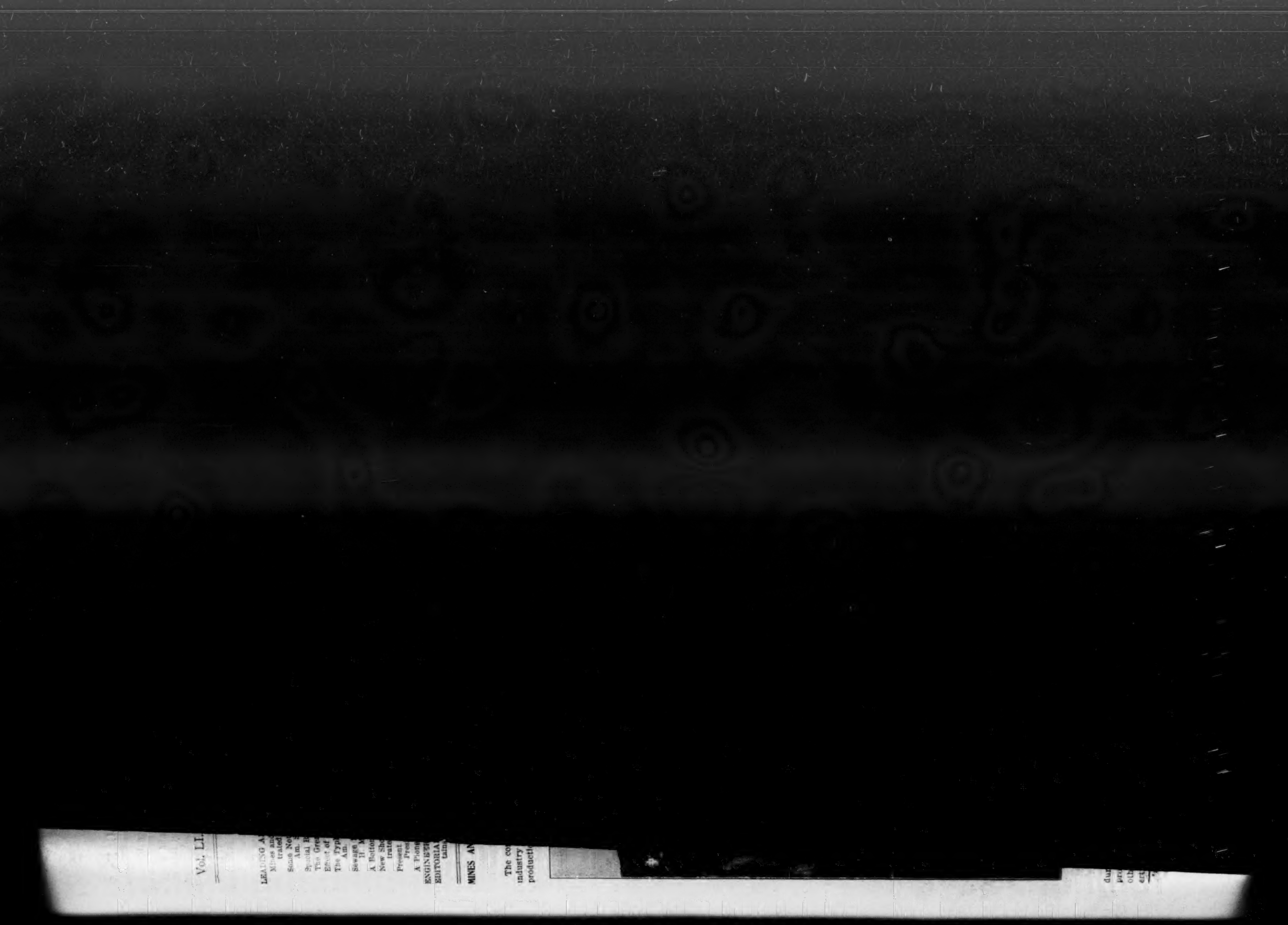


FIG. 1. METHOD EMPLOYED IN REPAIRING BADLY WORN SEWER INVERTS AT ST. LOUIS, MO.

*Lately Sewer Commissioner and Member of the Board of Public Improvements, St. Louis, Mo.